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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 10, October 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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Diet Model For Measuring Radioactivity Exposure Through Food—Pilot Study

R. C. Steinkamp,¹ N. L. Cohen,² E. Hutson,³ and H. Kunkel³

This paper reports a pilot study designed to test the hypothesis that the house diet of a hospital may serve as a model for the diet of an adult population regionally served by the hospital in order to measure radioactivity exposure through food intake. Yearly and seasonal quantities of 57 subcategories of nine major food groups were compared for a Berkeley hospital house diet and diets of Berkeley and other San Francisco Bay Area residents. Results indicate that the hospital house diets while differing in certain respects from food intake of the population, may provide an estimate of near-maximum intake of foods significant for radioactive content.

Prior to 1964, individual foods, including milk and water, produced or consumed within the State of California were monitored by the Bureau of Radiological Health and the Sanitation and Radiation Laboratory. This system provided no knowledge of food intake and therefore the determination of radioactivity consumed through the total diet was limited. Consequently, a different approach is necessary in order to provide adequate information upon which to formulate policies protective to the general health of the population.

Readily available and accurately collected total diets representative of the population living in several areas of the State are needed for study.

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Other agencies are monitoring total diets by analyzing: (1) seasonal market-basket samples (1) for which types and amounts of food are based on U.S. Household Consumption Records; (2) a "standard" diet in Connecticut (2); and (3) diets sampled from school institutions (3). These three approaches have merit, but not one of them satisfies the peculiar needs for continuing diet sampling programs within California.

No single "master" diet can be representative for the whole State. Diet practices differ. Areas with greater rainfall have a higher radioactive fallout resulting in higher radioactivity in foods grown within the areas. For monitoring purposes, representative diets should reflect the maximum or near maximum potential for radioactivity obtained through food. Since radioactivity varies from time to time, it is imperative that diets be available for sampling throughout the year.

In order to meet these prerequisites, house diets of 20 regional hospitals in different geographic areas of California were selected for

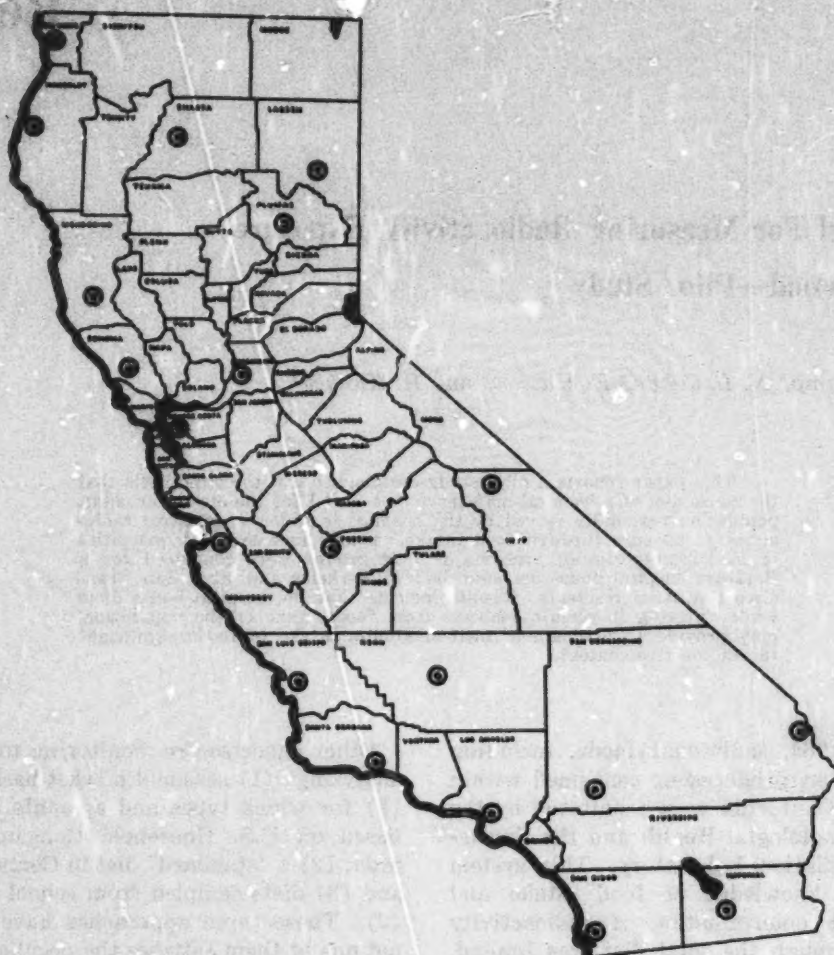


Figure 1. Location of the 20 participating hospitals for radioactivity monitoring of diet in California

total-diet sampling. Figure 1 shows these locations. House diets of regional hospitals may reflect the diets of the population served by the hospital (exclusive of infants and young children). Hospitals operate and serve food each day of the year. Hospital personnel trained in dietetics are available to collect the diets. Furthermore, they are motivated toward health needs and protection of health and are willing to cooperate in sampling studies.

This study has attempted to explore the hypothesis that house diets of a given hospital may

serve as a model of food consumption by an adult population regionally served by the hospital and that such diets may represent the maximum or near maximum exposure to radioactivity through food. Inherent to this hypothesis is the assumption that food sources available to the hospital and to the regional population are similar. This has also been explored. House diets of the 19 hospitals for which regional population diet records were unavailable have also been compared with the house diet of the hospital used as the basis of this study.

Materials and methods

All food constituting a single house diet (all meals and nourishments) for a 7-day period was collected every 2 months for a period of 1 year by trained personnel. Records of type, amount and preparation for each food served in a single house diet for each collection period were kept by the dietitian or another individual responsible for the collection procedure. The records for the Berkeley Hospital were the basis for this study. Food was weighed in ounces or measured in cups, tablespoons, or other household units. Recipes of composite foods were noted to obtain approximate amounts of individual foods.

Individual diet recall records for adults living in the San Francisco Bay Area obtained in a previous study (4,5) were used to represent diets of people regionally served by the Berkeley Hospital. The recall records denoted quantity as well as food preparation methods and composition of mixed dishes. One-day records for 483 men and women, aged 25 to 44 years, were divided according to three areas of residence: Berkeley, other Alameda County, and other Bay Area.

Table 1 presents the number of menus for all hospitals and the number of individual consumption records based on 1-day food recalls for the various population groups on a bi-monthly interval. The Berkeley Hospital records were complete for all time intervals. Occasionally, throughout the year, records were not complete for several of the other hospitals. Appropriate corrections were made to account for only complete records.

The amounts of food recorded for the Berkeley Hospital menus and for individual subject records were compared for 100-gram portions

Table 1. Number of weekly menus and individual food-recall records by month of year

	Jan-Feb	Mar-Apr	May-June	July-Aug	Sept-Oct	Nov-Dec	Total days
Hospital weekly menus	19	17	20	19	20	18	791
Individual 1-day recall records:							
Berkeley	9	3	13	25	32	10	142
Other Alameda County	6	23	50	44	18	11	150
Other Bay Area Counties	12	57	52	36	27	7	191

Table 2. Food categories by radioactive fallout potential

Milk and milk products
Fresh whole milk
Fresh skim milk
Canned milk
Dry skim milk
Cottage cheese
All other cheese
All other dairy products, including ice cream and sherbet
Creamed dishes and creamed soups
Animal protein foods
Beef, pork, lamb, veal, organ meats, poultry
Fish
Shellfish
Bacon and sausage
Eggs
Legumes
Dried peas, beans and nuts
Vegetables
Leafy green
Underground vegetables, including mixed vegetables
Above ground vegetables
Kernal corn
Fruit
Not peeled, including jams and jellies
Peeled
Grain products
Whole grain products, and those with any proportion of whole grain, including corn meal
Refined cereal products
Combination foods
Fruit pie
Cream pie
Other pie
Meat and grain products
Meat and vegetables
Meat, vegetables and grain products
Fats and oils
Vegetable oils and salad dressings
Margarine
Butter
Animal fat
Miscellaneous
Honey
Gelatin and plain gelatin products
Gelatin with fruits or vegetables
Soups other than creamed
All other foods and beverages

and were coded within nine major food groups with a total of 37 subcategories (table 2) arbitrarily grouped according to similarity of potential for radioactive fallout or pesticide residue.⁴ Similar comparison was made for the Berkeley Hospital menus and the averages for menus of the 19 other hospitals by time interval.

A questionnaire was administered to the hospital food buyer to determine sources, brands and purchasing practices of food. A similar questionnaire was administered to the managers and buyers of three large food chain stores and two neighborhood food stores⁵ in Berkeley in order to determine food sources

⁴ Performed by Food and Drug Laboratory on selected samples of diets.

⁵ The Berkeley Market, Consumers Cooperative of Berkeley, Lee Brothers Market, Safeway Stores and Varsity Food Market.

available to the reference population group. These markets represent the major retail food stores in the Berkeley area. Additional information was obtained from wholesale food companies.

Analysis of purchasing practices provided for comparison of the sources of foods available to the Berkeley Hospital with those available to the reference population through the local markets.

Results

Table 3 presents the yearly means and ranges in 100-gram portions per day for nine major food groups for the Berkeley Hospital and the Berkeley residents. Results of the other two population groups were similar to those for the Berkeley residents. The Berkeley Hospital menus had a smaller range for all food groups except milk and milk products than any one of the three population groups. The exception for milk is explained by the fact that during the first months of collection, fluid milk was not included in the collection sample each time it was available on the house diet menu. For only three food groups (animal protein foods, legumes, and combination foods) was the mean daily serving per year lower for the hospital house diet than for the Berkeley residents. The Berkeley Hospital menus provided a daily average of 206 grams of animal protein foods, 4 grams of legumes and 42 grams of combination foods. Comparable figures for the Berkeley residents were 213, 11, and 81 grams, respectively. Miscellaneous foods comprised for the most part, coffee, tea, and soups other than creamed soups. No gelatin was used by the Berkeley Hospital or the general population.

Table 3. Means and ranges for major food groups in 100 g portions/day for the Berkeley Hospital and the Berkeley residents

Food groups	Berkeley Hospital		Berkeley residents	
	Mean	Range	Mean	Range
Milk and milk products	6.34	4.18-8.26	3.59	2.00-5.48
Animal protein foods	2.06	1.85-2.21	2.13	1.39-2.90
Legumes	.04	.01-.09	.11	0-.32
Vegetables	3.76	3.22-4.39	1.97	1.22-2.76
Fruits	2.88	2.14-3.44	2.17	1.25-3.43
Grain products	3.48	3.21-3.93	2.21	1.10-3.48
Combination foods	.42	0-.90	.81	0-3.00
Fats and oils	.54	.50-.61	.27	0-.50
Miscellaneous	12.44	8.00-24.80	11.80	1.20-24.40

Alcoholic beverages were included in miscellaneous foods for the general population but did not appear on hospital menus.

While the average daily amount of all milk and milk products used by the Hospital was almost twice that of the Berkeley subjects, 634 grams as compared to 359 grams, the average amounts of fluid whole milk were quite similar, 236 and 222 grams, respectively. Means and ranges were also comparable for cottage cheese and all other cheese. The Berkeley Hospital used more canned milk, creamed dishes (including soups) and other dairy products (excluding butter) than did any of the three population groups. On the other hand, skim milk was not used by the hospital. The Berkeley and other Alameda County residents used about 40 grams of skim milk a day and all other Bay residents almost 100 grams.

The average daily animal protein food intake was remarkably similar for the hospital and the general population. There were slight variations among the sub-categories for this food group. The general population used more lean meats and fewer eggs than did the hospital, 145 and 33 g/day as compared to 123 and 53 g/day, respectively. The hospital used no shellfish; the general population's diets averaged 3 g/day.

Considerably less use was made of legumes in the hospital diet than in the population diets. The hospital menus had greater quantities of all other vegetables than did those of the resident groups. For leafy green vegetables, vegetables grown underground and those grown above ground, the hospital average was almost twice that of the population. Hospital use of kernel corn was only slightly higher than that used by the population.

Seasonal variation for 15 of the 37 food groups is presented in figure 2 for Berkeley Hospital menus, for averages of menus of 19 other hospitals, for the Berkeley residents, and for all Bay Area residents. Food groups not shown in figure 2 were used in average amounts of less than 25 grams a day (fruit pie, cream pie, other pie, honey, fish, shellfish, animal fats, cottage cheese, and all other cheese), or were completely absent from the diets of either the hospital or the general population (combination dishes of meat and grain, plain gelatin, gelatin

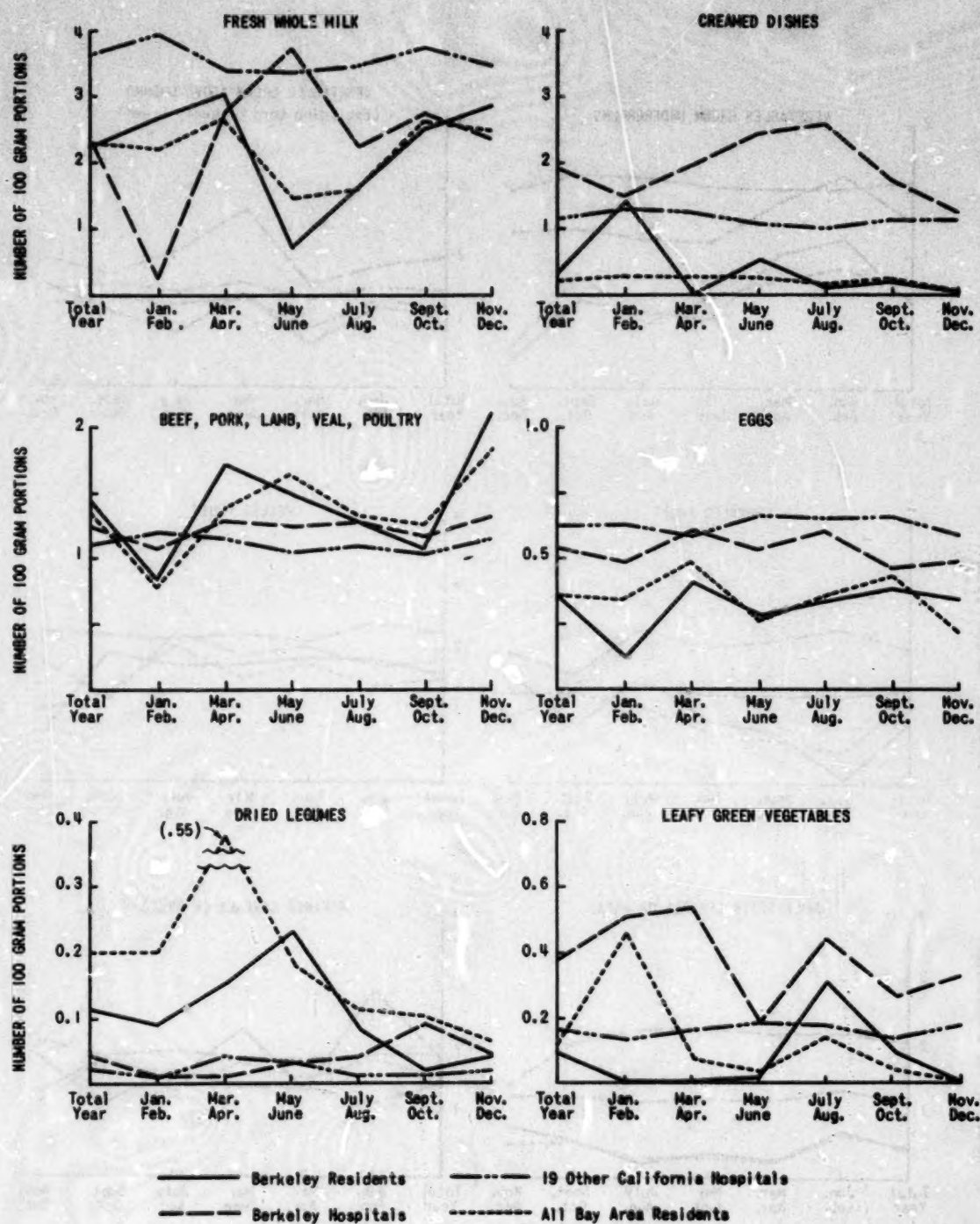


Figure 2. Daily food group means in 100-gram portions for a Berkeley Hospital, 19 other California hospitals, Berkeley residents and all Bay Area residents by year and bimonthly intervals

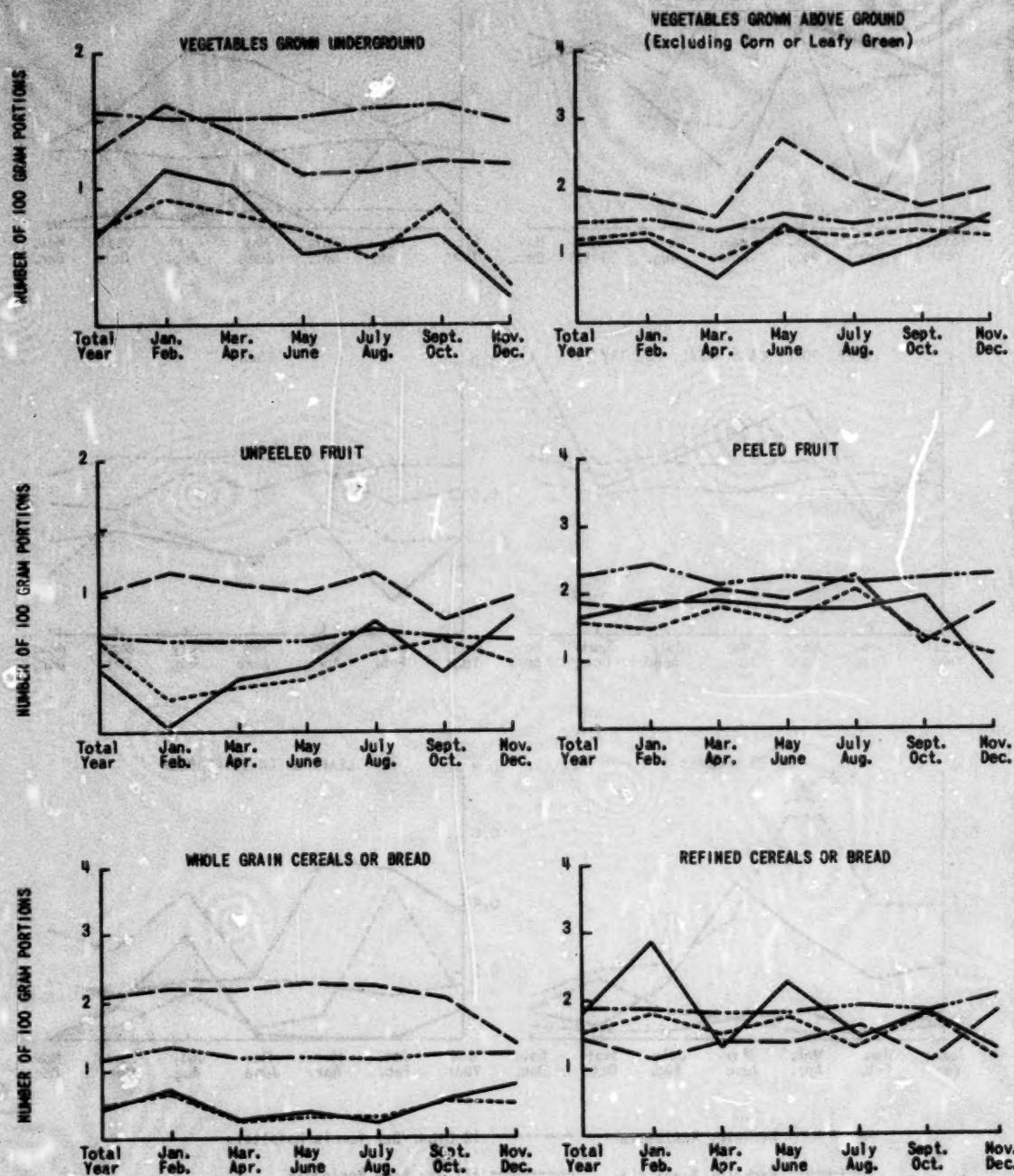


Figure 2. Continued—Daily food group means in 100-gram portions for a Berkeley Hospital, 19 other California hospitals, Berkeley residents and all Bay Area residents by year and bimonthly intervals

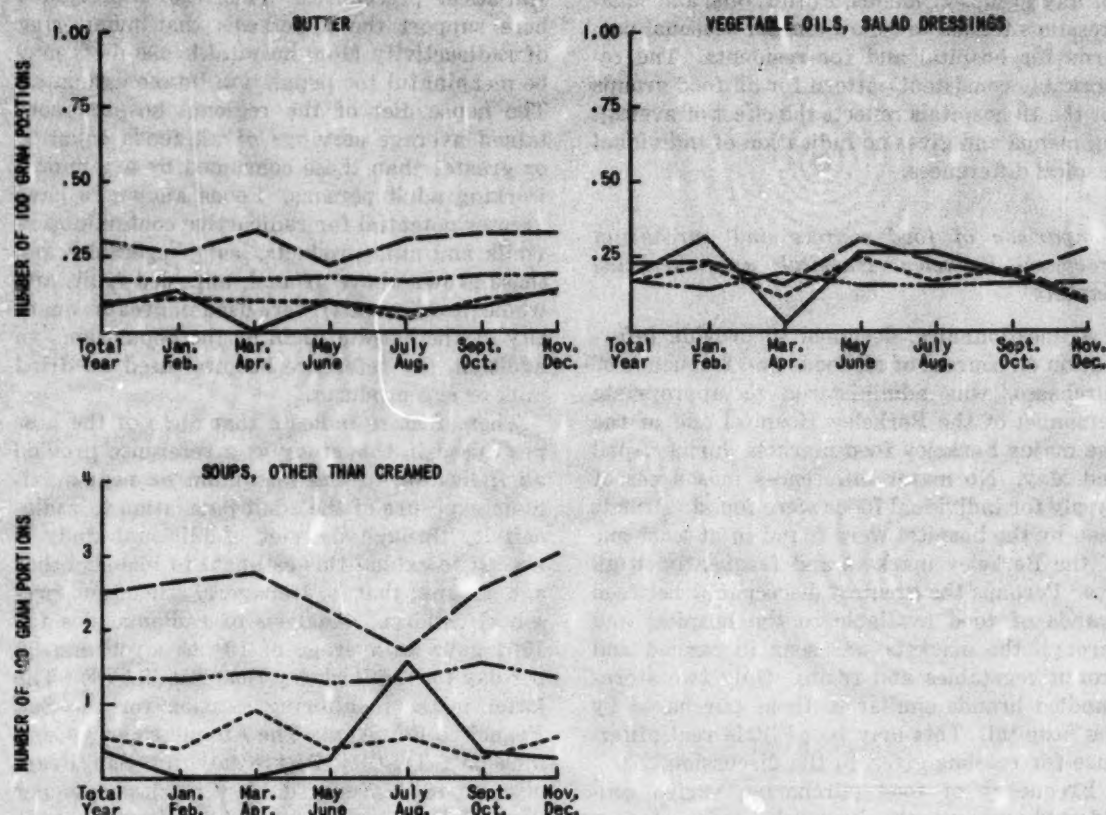


Figure 2. Continued—Daily food group means in 100-gram portions for a Berkeley Hospital, 19 other California hospitals, Berkeley residents and all Bay Area residents by year and bimonthly intervals

with fruit, and margarine). In addition, all other dairy products are not presented. This food group, consisting primarily of ice creams and sherbets, showed no seasonal variation and was used by the hospital in amounts over 5 times that used by the general population, 164 g/day as compared to 30 g/day.

The 15 food groups in figure 2 comprised the major part of the total daily menu. The Berkeley Hospital showed a wide variation in fresh whole milk, comparable to the Berkeley residents but at seasonally different times. The nadir for the residents occurred in May-June; the time of peak appearance of milk in hospital menus. Lean meats and eggs were at steady levels throughout the year for the Berkeley Hospital as well as all other hospitals. For the

residents, the lowest consumption of lean meats and eggs occurred in January-February. Among the vegetables there were remarkably comparable patterns for the Berkeley Hospital and the residents for both vegetables grown underground and those grown above ground, excluding leafy green vegetables. For the latter, great variation occurred during the year. The greatest discrepancies between hospital and resident menus occurred in the winter and spring months. The menus of Berkeley and other hospitals were consistent throughout the year for amounts of fruits of all kinds. The seasonal trends for fruit consumption were comparable for Berkeley residents and all Bay Area residents; for peeled fruits all menus were similar to the Hospital menus. Little variation

was found for whole grain cereals or breads for any groups of menus. Butter, oils, and salad dressings tended to follow similar seasonal patterns for hospital and for residents. The remarkably consistent pattern for all food groups for the 19 hospitals reflects the effect of averaging menus and gives no indication of individual hospital differences.

Comparison of food sources and purchasing practices—Berkeley Hospital and Berkeley markets

A questionnaire, designed to provide information on sources of all foods and frequency of purchases, was administered to appropriate personnel of the Berkeley Hospital and of the five major Berkeley food markets during April and May. No major differences in sources of supply for individual foods were found. Brands used by the hospital were found in at least one of the Berkeley markets and frequently in all five. Perhaps the greatest discrepancy between brands of food available to the hospital and through the markets was seen in canned and frozen vegetables and fruits. Only two stores handled brands similar to those purchased by the hospital. This may be of little real difference for reasons given in the discussion.

Frequency of food purchasing varied considerably among the hospitals, since storage facilities determine to a large extent their buying practices. In general, the Berkeley Hospital bought perishable foods 3 to 4 times a week, while frozen meat, poultry, and fish were bought once a month. Bread was purchased 5 to 6 times a week. Staples such as sugar, all canned foods, dehydrated foods, cereals, and oils were bought 4 to 6 times a year and flour once a month. Fresh, as well as frozen fruits and vegetables, were purchased 2 to 3 times a week.

The major difference between purchasing by food markets and by the Berkeley Hospital was that, in general, the food markets bought all foods more frequently than did the hospital.

Discussion

Estimates of diets representative for a population group are possible provided consideration is given to details of population sampling, to

accuracy of diet intake studies, and to careful statistical procedures. The results presented here support the hypothesis that monitoring of radioactivity from hospital house diets may be meaningful for population intake estimates. The house diet of the regional hospital contained average servings of all foods equal to or greater than those consumed by a group of working adult persons. Foods known to have greater potential for radioactive contamination (milk and milk products, leafy vegetables and those grown above ground, unpeeled fruit, and whole grain cereals) were used in greater quantity by the hospital than by the population. In addition, the reference hospital used no dried milk or egg products.

These factors indicate that diets of the hospital used in this study as a reference provide an indication of the maximum or near-maximum exposure of the adult population to radioactivity through the diet. Additional study is needed to extend this estimate to include other age groups; that is, teenagers, school and preschool children. Analysis of radionuclides for 1964 gave an average of 19 pCi strontium-90 per day for the Berkeley Hospital diet (6). The latter is the monitoring location for the San Francisco Bay Area. The Atomic Energy Commission's Tri-City Diet Study for San Francisco in 1964 averaged 14 pCi per person per day. This compares favorably with the above results.

Additional support for the use of hospital house diets for radioactivity monitoring of population exposure through diet is provided by the data on sources of food available to the hospital and to the general population. For the majority of foods, the places of origin available to hospitals appear to be similar to those in the local markets. Several factors were identified which may indicate that the sources of supply were even more similar than is evident. Chain food markets often use their own label for the same products sold in the area by others under a different label. Vegetables and fruits, picked from the same crop, may be packaged under several different labels. Labels for foods packed in large quantity as used by hospitals may differ from labels used for smaller-sized containers as sold in retail stores, although the foods may originate from the same crop.

One factor needing further investigation is the storage life of foods as used in hospital house diets with relation to that used by the general population. It is conceivable that certain of the short-lived radionuclides may be lower in hospital diets as a result of longer storage before use. This, however, would seem to be of minor importance as long as above ground nuclear testing is not resumed. Another possible factor is the likelihood that hospitals may use dried milk and eggs more often than the general population. These foods may contain radioactive contaminants from a different time period than fresh milk and eggs.

Conclusion

This pilot study suggests that a model for measuring the near-maximum intake of foods significant for the determination of radioactive content of an adult population group may be derived from the house diet of a hospital serving the region from which the population group is selected. Additional study needs to be done using a randomly selected population group in-

cluding children as well as adults. Other geographic regions should be investigated in order to substantiate the findings of this pilot study. Sources and storage life of foods must be more completely evaluated than was possible here.

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Technical Notes

Plutonium and Strontium-90 in Precipitation, August 1966 through March 1967

H. Levine, W. P. Kirk, and H. J. L. Rechen¹

The Radiation Surveillance Network (RSN) of the National Center for Radiological Health, U.S. Public Health Service, Rockville, Md., initiated in August 1966, routine measurements of the amounts of total plutonium and strontium-90 in precipitation samples as part of its mission to establish, maintain, and operate a national surveillance network to report radioactivity in surface air and precipitation (1). These measurements are concurrent with the measurements of plutonium in airborne particulates initiated in 1965 and reported previously (2). Plutonium and strontium-90 are long-lived nuclides injected into the atmosphere, principally by the detonation of nuclear devices (3). Plutonium analyses of precipitation samples are done partly for comparison with data from corresponding air samples and because together with the analyses for strontium-90, they provide an indication of the deposition of long-lived radionuclide fallout by precipitation in the United States.

Eight RSN stations submit complete collections of precipitation for analysis. Funnels of 0.4 m² area are used to collect 24-hour precipitation samples. The daily collection, if any, is

measured, placed in one or more plastic containers and mailed to the NCRH Special Studies Laboratory at Rockville, Md. Upon receipt at the laboratory, 500 ml or 50 percent of the mixed sample (whichever is less) is evaporated to dryness on a 10-cm diameter planchet and the gross beta radioactivity is counted in a thin-window, low-background, gas-flow proportional counter. The remainder of the sample is set aside until all samples for that month have been received. After the total monthly volume of precipitation for the station is known, a monthly composite sample is prepared for each station by combining calculated quantities of each of the daily samples in an 18-liter carboy.

A 100- to 1,000-ml aliquot is taken from each monthly composite and sent to the Southeastern Radiological Health Laboratory to be analyzed for tritium. The remainder of each composite is analyzed for total plutonium using the procedures of Levine and Lamanna (4) as modified below and for strontium-90 with standard procedures (5).

The samples are evaporated to dryness, and the residues are brought completely into solution with nitric acid—hydrofluoric acid treatment, converted to the chloride ion and brought to volume in a volumetric flask. The solution is then divided into two aliquots, 70 percent and 30 percent, and each aliquot undergoes analysis separately for total plutonium. The

¹ Mr. Levine is chief radiochemist, Electronic Products Radiation Laboratory, Technical Services Branch, NCRH; Mr. Kirk, chief, Radiation Surveillance Network, Environmental Surveillance and Control Program, NCRH; and Mr. Rechen, deputy chief, Electronic Products Radiation Laboratory, TSB, NCRH.

Table 1. Plutonium and strontium-90 in precipitation, August 1966-March 1967

	Station location							
	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Honolulu	Seattle
Precipitation depth (mm.) 1966								
August	45	41	55	250	101	38	16	8
September	101	44	24	208	102	42	0	23
October	96	46	16	80	25	8	19	40
November	23	46	7	13	2	7	55	94
December	50	71	0	158	30	4	70	148
1967								
January	69	32	0	89	0	12	23	120
February	81	40	0	35	30	8	105	81
March	61	97	0	31	32	17	168	70
Total plutonium concentration (pCi/liter) 1966								
August	0.012	0.081	ND	0.016	0.018	0.020	0.022	(*)
September	.018	.036	ND	.014	.013	.011	NS	ND
October	.012	.020	(*)	.013	ND	(*)	.005	.007
November	.020	.012	(*)	.017	(*)	(*)	.003	ND
December	.023	.008	NS	.007	.008	(*)	.004	.004
1967								
January	.015	.014	NS	.016	(*)	.039	.011	.005
February	.011	.046	NS	.016	.014	(*)	.010	.013
March	.019	.023	NS	.033	.040	.029	.033	.019
Strontium-90 concentration (pCi/liter) 1966								
August	0.36	0.94	(*)	0.79	0.63	(*)	NS	(*)
September	.67	1.60	(*)	.48	.58	3.50	NS	.63
October	.76	.46	(*)	.30	.38	(*)	0.61	2.23
November	(*)	.67	(*)	(*)	(*)	(*)	.40	1.28
December	2.14	2.48	NS	1.11	4.60	(*)	1.23	
1967								
January	2.58	7.94	NS	4.09	(*)	26.2	4.18	4.00
February	1.13	1.73	NS	.71	1.51	(*)	1.19	1.35
March	1.56	1.41	NS	1.88	3.30	3.03	.76	1.68
Total plutonium deposition (pCi/m ²) 1966								
August	0.84	1.39	ND	4.26	1.53	0.56	0.36	(*)
September	1.80	1.66	ND	3.14	1.18	.47	NS	ND
October	1.16	.90	(*)	.98	ND	(*)	.16	.27
November	.44	.57	(*)	.20	(*)	(*)	.43	ND
December	1.13	.58	NS	.95	.17	(*)	.31	.60
1967								
January	1.03	.44	NS	1.30	NS	.46	.37	.71
February	.90	1.81	NS	.57	.41	NS	1.03	.42
March	1.17	2.13	NS	1.01	.87	.49	3.85	1.31
Strontium-90 deposition (pCi/m ²) 1966								
August	38	38	(*)	205	64	(*)	(*)	(*)
September	68	46	(*)	113	59	151	NS	35
October	73	29	(*)	24	7	(*)	9	210
November	(*)	31	(*)	(*)	(*)	(*)	23	189
December	108	177	NS	153	92	(*)	86	
1967								
January	178	255	NS	356	NS	312	138	600
February	91	70	NS	24	45	NS	122	42
March	98	126	NS	58	73	52	127	117

* Insufficient sample. Analysis was not done because the volume of sample available was not large enough to justify the work. In a number of cases, there was sufficient sample to do the plutonium analysis, but not enough to do both.
 ND, nondetectable. An analysis was performed but the amount of radioactivity present was below the limit of detectability, defined as the count which will be exceeded 5 percent of the time by a sample containing no radioactivity (9). In the case of the plutonium analyses, 1,000 minute counts were used. "ND" is equivalent to 0.005 pCi in the total sample. In general, a 5-liter sample is used so specific activity of less than 0.007 pCi/liter would not be detected. Those samples reported at less than 0.007 pCi/liter were larger than 5 liters. ND is not used in connection with strontium-90 in this report.
 NS, no sample received.

total radioactivity is the sum of the result for both aliquots. The chemical yield of the analytical procedure is approximately 80 percent as determined by reference samples. The samples are counted for 1,000 minutes in a 2-inch diameter, 0.080 mg/cm² window proportional counter.

The counting error at the 95-percent confidence level is less than 10 percent for most of the samples and the volume of the sample is known. The precision of the analytical procedure is estimated to be approximately 20 percent of the 1 pCi/liter level.

Table 1 gives the results of analysis for August 1966 through March 1967. The basic finding is the concentration (pCi/liter). This figure is multiplied by the depth of precipitation for the month (mm) to obtain the total deposition (pCi/m²).

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SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Both Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of ex-

posure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in

milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program
Radiostrontium in milk, HASL

Period reported
July–December 1966

Last presented
September 1967

1. Pasteurized Milk Network June 1967

*National Center for Radiological Health and
National Center for Urban and Industrial
Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN), was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) pro-

vides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent de-

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error * (pCi/liter)	Concentration (pCi/liter)	Error * (percent of concentration)
Strontium-90	<50	5	50	10
Strontium-90	<20	2	20	10
Iodine-131	<100	10	100	10
Cesium-137	<100	10	100	10
Barium-140	<100	10	100	10

* Two standard deviations.

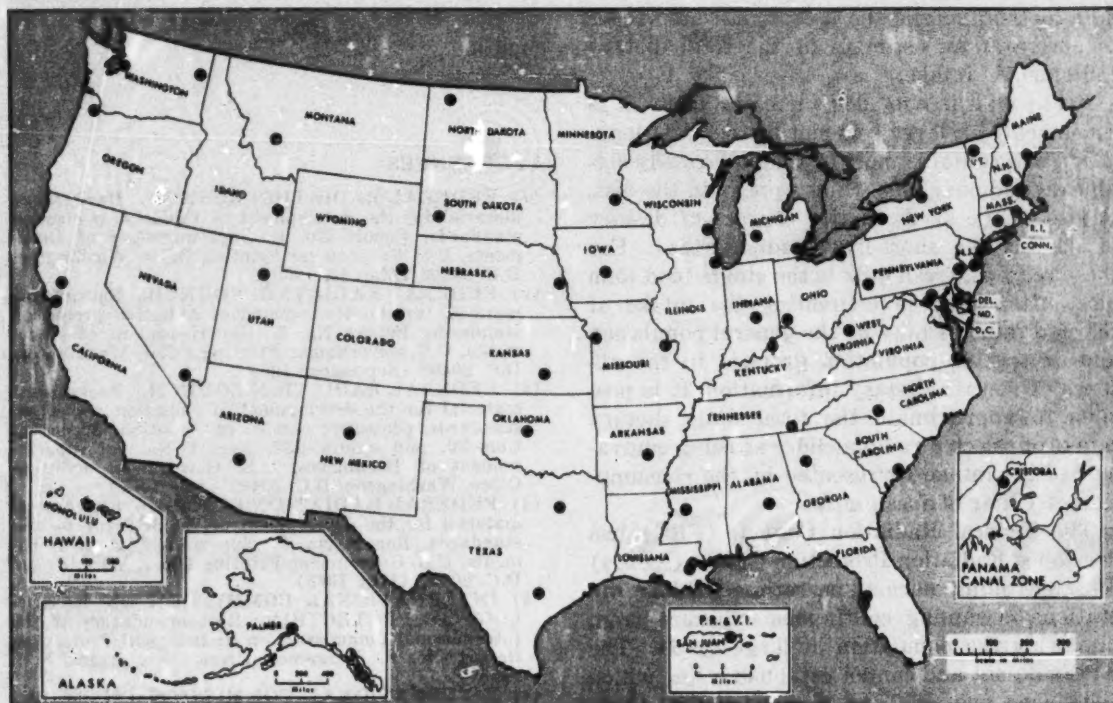


Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentration of radionuclides in pasteurized milk for the second quarter 1967 and June 1967 -

Sampling location		Concentrations (pCi/liter)					
		Strontium-90 ^b		Strontium-90		Cesium-137	
		Second quarter 1967	June 1967	Second quarter 1967	June 1967	Second quarter 1967	June 1967
Ala:	Montgomery	< 5	< 5	10	8	15	15
Alaska:	Palmer	< 5	< 5	7	7	30	15
Aris:	Phoenix	< 5	< 5	4	2	< 5	< 5
Ark:	Little Rock	< 5	< 5	37	25	30	35
Calif:	Sacramento	10	< 5	5	7	10	5
	San Francisco	10	< 5	5	5	10	5
C. Z:	Cristobal	< 5	< 5	5	4	30	15
Colo:	Denver	< 5	< 5	5	9	10	10
Conn:	Hartford			9	9	20	20
Del:	Wilmington	< 5	< 5	12	13	15	15
D. C:	Washington	< 5	< 5	10	10	15	10
Fla:	Tampa	< 5	< 5	9	8	75	50
Ge:	Atlanta	< 5	< 5	17	17	25	25
Hawaii:	Honolulu	< 5	< 5	4	3	10	10
Idaho:	Idaho Falls	< 5	< 5	7	7	10	10
Ill:	Chicago	< 5	< 5	10	8	15	10
Ind:	Indianapolis	< 5	< 5	10	9	15	10
Iowa:	Des Moines	< 5	< 5	9	9	15	10
Kans:	Wichita	< 5	< 5	8	10	10	< 5
Ky:	Louisville	< 5	< 5	15	15	10	10
La:	New Orleans	< 5	< 5	25	27	30	35
Maine:	Portland	< 5	< 5	12	13	35	40
Md:	Baltimore	< 5	< 5	13	13	20	20
Mass:	Boston	< 5	< 5	12	13	35	35
Mieh:	Detroit			9	9	15	15
	Grand Rapids			11	11	25	20
Minn:	Minneapolis	< 5	< 5	14	14	20	15
Miss:	Jackson	< 5	< 5	21	18	20	20
Mo:	Kansas City	< 5	< 5	10	12	10	5
	St. Louis	< 5	< 5	10	9	10	5
Mont:	Helena	< 5	< 5	6	6	10	10
Nebr:	Omaha	< 5	< 5	8	10	10	10
Nev:	Las Vegas	< 5	< 5	2	3	5	5
N. H:	Manchester			15	17	50	55
N. J:	Tronton	< 5	< 5	10	11	20	15
N. Mex:	Albuquerque	< 5	< 5	8	3	< 5	< 5
N. Y:	Buffalo			9	9	20	15
	New York City			12	11	20	20
	Syracuse			11	9	20	15
N. C:	Charlotte	< 5	< 5	9	9	20	20
N. Dak:	Minot	< 5	< 5	19	18	23	15
Ohio:	Cincinnati			17	13	15	10
	Cleveland			11	11	30	15
Okla:	Oklahoma City	< 5	< 5	12	13	10	10
Oreg:	Portland	5	10	10	9	20	20
Pa:	Philadelphia			10	11	15	15
	Pittsburgh			15	15	25	20
P. R:	San Juan	< 5	< 5	4	5	15	15
R. I:	Providence			11	11	25	30
S. C:	Charleston	< 5	< 5	16	15	35	40
S. Dak:	Rapid City	< 5	< 5	14	17	15	15
Tenn:	Chattanooga	< 5	< 5	17	17	20	20
	Memphis	< 5	< 5	16	16	10	10
Tex:	Austin	< 5	< 5	4	4	10	10
	Dallas	< 5	< 5	12	13	15	15
Utah:	Salt Lake City	< 5	< 5	6	7	15	15
Vt:	Burlington	< 5	< 5	11	11	25	20
Va:	Norfolk	< 5	< 5	14	15	15	15
Wash:	Seattle	< 5	< 5	12	11	35	20
	Spokane	< 5	< 5	12	13	20	15
W. Va:	Charleston	< 5	< 5	15	16	15	15
Wis:	Milwaukee	< 5	< 5	7	7	20	15
Wyo:	Laramie	< 5	< 5	5	7	10	10
Network average		< 5	< 5	10.9	10.9	30	20

* Iodine-131 and barium-140 concentrations for all stations were below the limits of detectability.
 * Blank indicates no strontium-90 determinations were made on samples from station during month.

scription of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The results for June 1967 and the second quarter of 1967 are presented in table 2. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (1), averages were calculated using one-half the minimum detectable values; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 3 and 4 for June 1966 and January through June 1967. The average strontium-90

Table 3. Frequency distribution, strontium-90 concentrations in milk at PMN stations June 1966, January-June 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966	1967					
		June	Jan	Feb	Mar	Apr	May
Under 10.....	9	24	21	25	35	35	37
10-19.....	41	36	38	35	34	35	34
20-29.....	10	3	4	2	4	3	2
30-39.....	3	0	0	1	0	0	0

concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 4. Frequency distribution, cesium-137 concentrations in milk at PMN stations, June 1966 January-June 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966	1967					
		June	Jan	Feb	Mar	Apr	May
Under 50.....	56	62	62	62	62	61	61
50-99.....	6	1	1	1	1	2	2
100-149.....	1	0	0	0	0	0	0

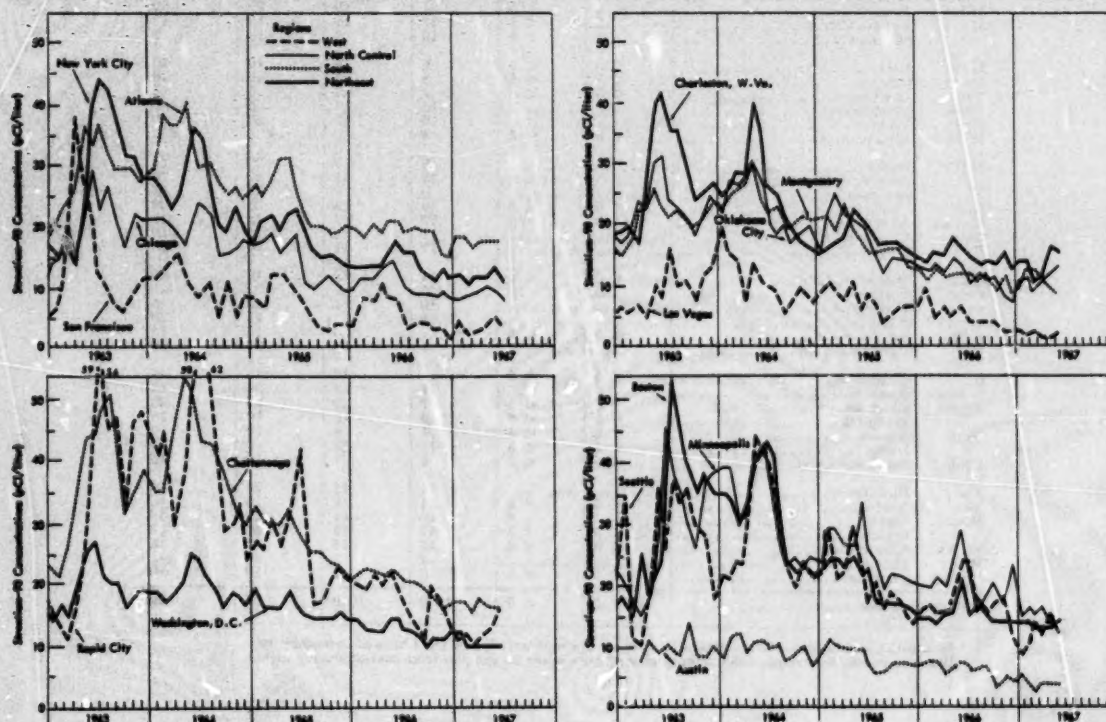


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-June 1967

2. Canadian Milk Network June 1967¹

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and

¹ Prepared from July 1967 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The June 1967 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, June 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary.....	1.08	1.6	14	28
Edmonton.....	1.09	1.5	11	30
Ft. William.....	1.08	1.4	18	44
Fredricton.....	1.09	1.4	24	34
Halifax.....	1.10	1.6	21	36
Montreal.....	1.07	1.4	14	26
Ottawa.....	1.13	1.4	11	21
Quebec.....	1.08	1.4	17	57
Regina.....	NS	NS	NS	NS
St. John's, Nfld.....	1.08	1.4	20	64
Saskatoon.....	1.09	1.6	13	26
Sault Ste. Marie.....	1.11	1.6	18	40
Toronto.....	1.13	1.6	8	24
Vancouver.....	1.15	1.5	23	74
Windsor.....	1.12	1.4	7	13
Winnipeg.....	1.18	1.6	11	14
Average.....	1.11	1.5	16	35

NS, no sample collected.



Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program June 1967

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).



Figure 4. Pan American Milk Sampling Program locations

Table 6 presents stable potassium, strontium-90, and cesium-137 monthly average concentrations for June 1967.

Table 6. Stable element and radionuclide concentration in PAHO milk, June 1967^a

Sampling station		Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:	Santiago.....	1	1.59	2	30
Colombia:	Bogota.....	1	1.59	3	3
Ecuador:	Guayaquil.....	1	1.47	< 1	< 5
Jamaica:	Kingston.....	NS			
	Mandeville.....	NS			
	Montego Bay..	1	1.37	12	235
Venezuela:	Caracas.....	1	1.52	2	10
	April 1967....	1	1.26	3	10
	May 1967....	1	1.71	3	10
	June 1967....	1			
Canal Zone:	Cristobal ^b	4		4	15
Puerto Rico:	San Juan ^b	4		5	15

^a Iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples. Strontium-90 was less than 5 pCi/liter for all samples.

^b For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone and San Juan, Puerto Rico, from the Pasteurized Milk Network, are presented.

NS, no sample collected.

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State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing develop-

mental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in the current issue are highlighted in the figure. A summary of State programs previously covered, the reporting period, and issue of appearance are as follows.

State milk network	Period covered	Last presented
California	January-March 1967	September 1967
Connecticut	January-March 1967	August 1967
Indiana	January-March 1967	August 1967
Iowa	January-March 1967	August 1967
Michigan	January-March 1967	August 1967
Minnesota	January-March 1967	August 1967
New York	January-March 1967	August 1967
Oklahoma	January-March 1967	July 1967
Oregon	January-March 1967	September 1967
Pennsylvania	January-March 1967	August 1967
Washington	January-March 1967	September 1967

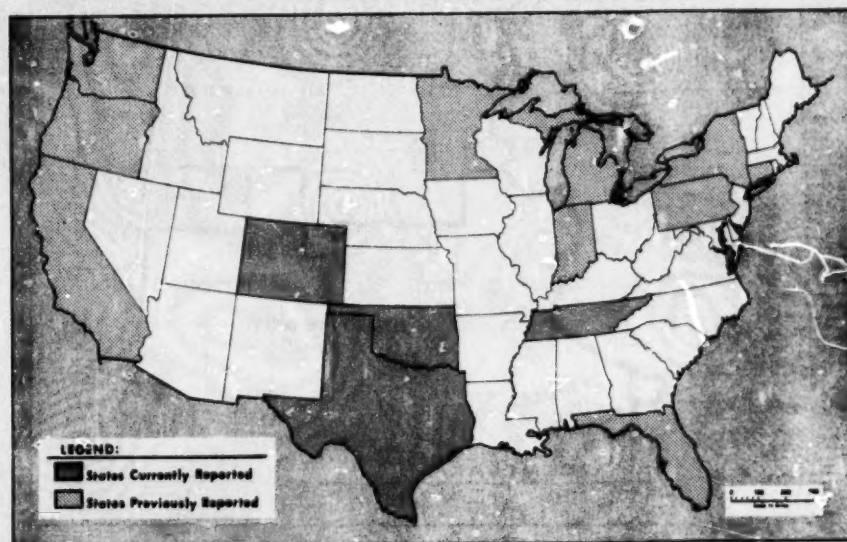


Figure 1. Reported State milk programs

1. Colorado Milk Network **April-June 1967**

*Occupational and Radiological Health Division
Colorado State Department of Public Health*

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially, the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State; northeast, southeast, west Colorado, and east Utah. Areas presently sampled are the west, south central, northeast and east Colorado (including northwest Kansas). Colorado milkshed areas are shown in figure 2.

Analyses are performed for iodine-131, barium-140, cesium-137, and potassium by gamma-ray spectroscopy. The measurement system previously reported (1) has been adapted to utilize a 4- by 5-inch NaI crystal shielded by a leadlined bank safe.

Minimum detectable amounts at the 2 standard deviation counting-error equivalent are: iodine-131, 10 pCi/liter; cesium-137 and barium-lanthanum-140, 15 pCi/liter; and potassium, 0.2 g/liter.

Barium-lanthanum-140, iodine-131 and potassium were not detected during the period April-June 1967. On June 13, one of four samples collected in northeastern Colorado showed a concentration of 29 pCi/liter of cesium-137.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
May 1965-June 1966	October 1966
January-March 1967	July 1967

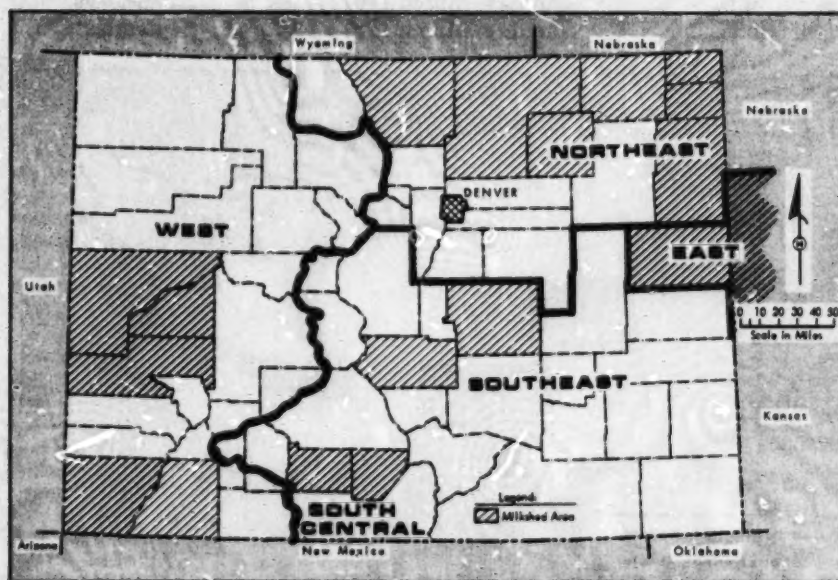


Figure 2. Colorado milk sampling areas

2. Florida Milk Network Summary 1966 and January-June 1967

Division of Radiological Health Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine-131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium-89, strontium-90, cesium-137, barium-140 and potassium, in addition to iodine-131. Monthly samples are taken from randomly selected farms in each of the six regions shown in figure 3. A regional State Board of Health Laboratory is located in each of the six regions referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These com-

posite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are also collected and analyzed for iodine-131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium-89 and strontium-90 are determined by the ion exchange method developed by Porter, *et al* (2). Iodine-131, cesium-137, barium-140 and potassium are determined by gamma-ray spectrometry (3).

Radionuclide concentration levels for January through March 1967, are presented in table 1 and April through June 1967 are pre-



Figure 3. Florida milk sampling areas

Table 1. Stable element and radionuclide concentrations in Florida raw milk, January-March 1967

Sampling location in Florida	Potassium (g/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
West.....	1.30	1.39	1.31	NA	27	NA	ND	<10	ND	50	20	27	ND	<10	ND
North.....	1.50	1.28	1.47	NA	21	NA	ND	<10	ND	33	21	42	ND	19	ND
Northeast.....	1.65	1.50	1.48	NA	14	NA	ND	<10	ND	100	95	87	ND	<10	ND
Central.....	1.47	1.18	1.33	NA	13	NA	ND	<10	ND	91	85	78	ND	<10	ND
Tampa Bay area.....	1.39	1.68	1.48	NA	21	NA	ND	<10	ND	104	95	107	ND	12	ND
Southeast.....	1.05	1.34	1.48	NA	9	NA	ND	<10	ND	111	77	104	ND	<10	ND
Average.....	1.46	1.40	1.45		17			* 10		83	82	74		* 12	

* <10 averaged as 10.
NA, no analysis.
ND, none detected.

Table 2. Stable element and radionuclide concentrations in Florida raw milk, April-June 1967

Sampling location in Florida	Potassium (g/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun
West.....	1.48	1.59	1.50	NA	22	19	ND	ND	ND	26	21	47	ND	ND	26
North.....	NS	1.49	1.43	NS	19	21	NS	ND	ND	NS	49	43	NS	ND	ND
Northeast.....	1.33	1.54	1.58	NA	14	7	ND	ND	ND	117	112	107	NS	ND	ND
Central.....	1.41	1.67	1.63	NA	8	9	ND	ND	ND	106	75	106	NS	ND	ND
Tampa Bay area.....	1.52	1.42	1.61	NA	9	10	ND	ND	30	112	89	117	NS	ND	ND
Southeast.....	1.42	1.54	1.51	NA	NA	10	ND	ND	ND	104	63	85	NS	ND	ND
Average.....	1.43	1.54	1.56		14	13			<10	93	68	85			<10

NA, no analysis.
ND, none detected.
NS, no sample.

sented in table 2. Strontium-89 analyses have been discontinued since 1965 due to extremely low levels. Table 3 provides a summary of average monthly concentrations during the calendar year 1966.

Table 3. Monthly average radionuclide concentrations in Florida raw milk, calendar year 1966 *

Month 1966	Radionuclide concentration (pCi/liter)		
	Strontium-90	Iodine-131	Cesium-137
January.....	17	ND	89
February.....	17	ND	95
March.....	17	ND	89
April.....	16	<10	91
May.....	15	<10	90
June.....	17	<30	95
July.....	13	<30	95
August.....	12	<10	148
September.....	13	<10	144
October.....	NA	<10	133
November.....	NA	<10	107
December.....	NA	<10	108

* <10 averaged as 10.
ND, none detected.
NA, no analysis.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January-March 1966	July 1966
April-June 1966	October 1966

3. Oklahoma Milk Network April-June 1967

Oklahoma State Department of Health¹

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine-131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium-137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 4. Of the 10 milksheds in the State of Oklahoma, 5 were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the concentration of radioactivity might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 4, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected on Monday morning, and the analyses are com-

pleted by Wednesday afternoon. However, if iodine-131 or cesium-137 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

Analytical method

The method of analysis is similar to that recently published by the U.S. Public Health Service (4) but was developed independently

Table 4. Concentration of cesium-137 in Oklahoma pasteurized milk, April-June 1967

(pCi/liter)

Sampling date	Sampling location				
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore
April 7-----	ND	12	13	9	ND
14-----	16	17	14	10	10
21-----	ND	44	42	10	41
28-----	NS	NS	NS	NS	NS
May 5-----	NS	NS	NS	NS	NS
12-----	NS	NS	NS	NS	NS
19-----	ND	ND	ND	ND	17
26-----	ND	ND	ND	ND	ND
June 2-----	36	ND	21	ND	NS
9-----	ND	ND	12	ND	ND
16-----	ND	ND	ND	ND	ND
23-----	ND	ND	ND	ND	NS
30-----	ND	NS	ND	ND	ND

ND, non detectable—less than 3 pCi/liter.
NS, no sample collected.

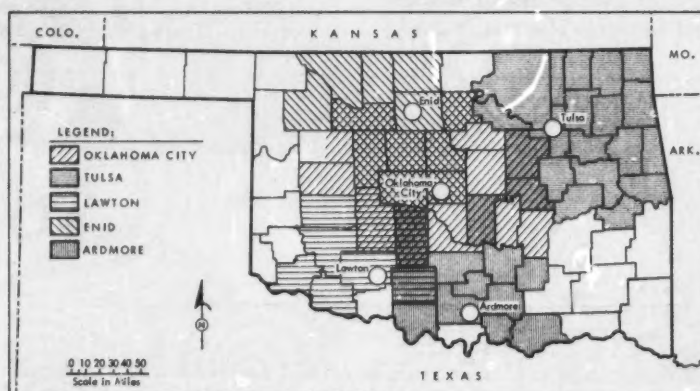


Figure 4. Oklahoma milkshed sampling areas

by the Oklahoma State Health Department's Radiological Health Laboratory and has not been published to date. Details of the procedure used were published earlier (5).

Results and discussion

Concentrations of iodine-131 found in Oklahoma milk samples collected from April through June 1967 were below detectable con-

centrations of 3 pCi/liter except for one sample collected on April 21, 1967, at Lawton that contained 7 pCi/liter. Cesium-137 concentrations are presented in table 4.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
October-December 1966	April 1967
January-March 1967	July 1967

4. Tennessee Milk Network April-June 1967

*Division of Preventable Diseases
Department of Public Health,
State of Tennessee*

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from three cities (figure 5). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample of milk is collected from each milk distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The semimonthly milk samples from each city sampled are analyzed by gamma-ray scintillation spectrometry for potassium-40, iodine-131, cesium-137, and barium-140, using a 31½

liter sample. After gamma-ray analysis, the samples are stored for 2 weeks to allow ingrowth of daughter radioactivity, after which strontium-89, strontium-90, and barium-140 concentrations are determined radiochemically using ion-exchange procedures. Chemical analyses are also made for stable calcium and potassium.

It should be noted that the Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of an aliquoted sample provides a cross check between the two laboratories.

Results

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 5 for the period of April through June 1967.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July 1965-June 1966	April 1967
January-March 1967	July 1967

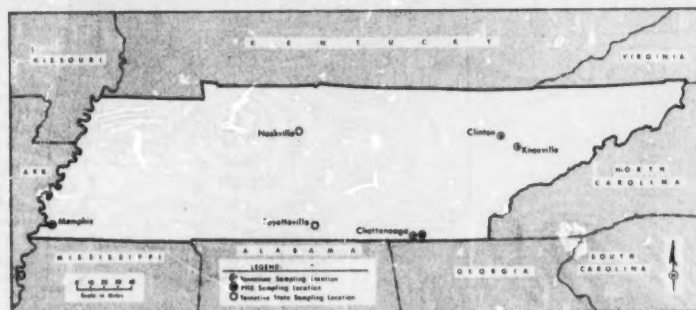


Figure 5. Tennessee pasteurized milk sampling stations

Table 5. Radionuclides in Tennessee pasteurized milk, April-June 1967

Location	Month 1967	Concentration (g/liter)	Radionuclide concentration (pCi/liter)					
			Potassium-89	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140
Chattanooga	April	1.8		7	17	< 8	23	< 5
	May	1.4		< 5	37	17	25	< 5
	June	1.4		< 5	26	11	23	< 5
Clinton	April	1.4		< 5	18	25	22	< 5
	May	1.4		< 5	24	< 8	29	< 5
	June	1.4		< 5	39	< 8	23	< 5
Knoxville	April	1.4		< 5	16	15	16	< 5
	May	1.5		< 5	16	8	20	< 5
	June	1.4		< 5	18	< 8	23	< 5

5. Texas Milk Network April-June 1967

*Texas State Department of Health*²

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present,

² Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

monthly samples of raw milk are collected from each of seven "active" sampling points. In addition, six "standby" stations are collecting raw milk samples once each calendar quarter. The station locations shown in figure 6 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium-90 by a chemical separation technique employing ion exchange columns (6). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.



Figure 6. Texas milk sampling stations

Potassium-40, iodine-131, barium-140, and cesium-137 concentrations are determined by gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium-iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5 liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium-40, strontium-90 and cesium-137 results by station and month for April through June 1967, are presented in table 6. During this time, the iodine-131 and barium-140 concentrations were below their limits of detectability

(10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through June 1967, is presented in figure 7.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operations indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (7).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	April 1967
and annual summary 1966	July 1967
January-March 1967	

Table 6. Radionuclide concentrations in Texas raw milk network, April-June 1967

Sampling location	Radionuclide concentration (pCi/liter)								
	Potassium-40			Strontium-90			Cesium-137		
	April	May	June	April	May	June	April	May	June
Austin.....	1,290	1,260	1,400	5	4	4	6	5	3
Fort Worth.....	1,270	1,370	1,310	5	9	4	5	ND	ND
El Paso.....	1,310	1,310	1,330	3	2	2	5	5	5
Harlingen.....	1,270	1,290	1,290	3	2	2	5	5	ND
Houston.....	1,360	1,370	1,350	10	10	8	15	20	15
Lubbock.....	1,290	1,350	NS	5	5	NS	10	5	NS
San Antonio.....	1,360	NS	1,330	4	NS	5	5	NS	ND
Average.....	1,310	1,330	1,370	5	5	4	7	7	4

ND, nondetectable.
NS, no sample collected.

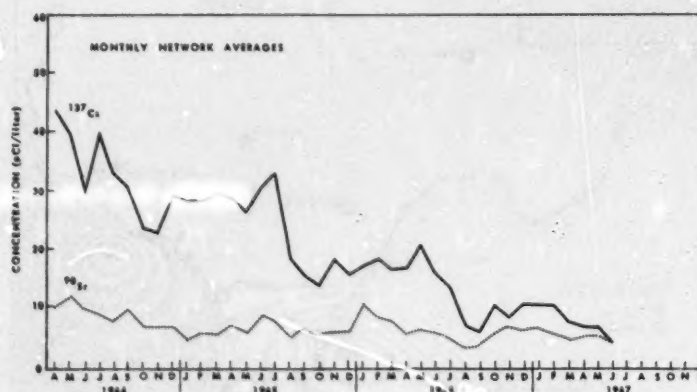


Figure 7. Radionuclide concentrations in Texas milk, April 1964-June 1967

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing

estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Last presented
Connecticut Standard Diet	July-December 1966	May 1967
Teenage Diet, FDA	February-November 1965	August 1966
Tri-City Diet, HASL	August-December 1966	September 1967
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

1. Radionuclides in Institutional Diet Samples Annual Summary 1966 and January-March 1967

National Center for Radiological Health Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered

by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (1).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be



Figure 1. Institutional diet sampling locations as of July 1965

selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily intake of teenage girls and children from 9 to 12 years of age were comparable while teenage boys consumed 20 percent more food per day (1,2). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev., Southeastern Radiological Health

Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented elsewhere (3).

Results

Table 1 presents the analytical results for institutional diet samples collected from January through March 1967, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of strontium-89, strontium-90, cesium-137, and radium-226 are expressed as pCi/kg of diet. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period, where applicable.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. For the purpose of obtaining

Table 1. Stable elements and radionuclide concentrations in institutional total diets of children, January-March 1967

Location of institution	Month 1967	Stable elements (g/kg of diet)		Radionuclide concentrations (pCi/kg of diet)			
		Calcium	Potassium	⁹⁰ Sr	¹³⁷ Cs	¹³⁴ Cs	²²⁶ Ra
Alaska: Palmer	Jan	0.4	1.1	<5	8	20	0.4
	Feb	.7	1.1	<5	13	25	.8
	Mar	.3	1.4	5	13	45	.6
Aris: Phoenix	Jan	.7	1.1	<5	6	10	.6
	Feb	.6	1.1	<5	5	<5	.6
	Mar	.5	1.7	<5	3	<5	.4
Ark: Little Rock	Jan	.7	1.7	NA	13	20	.8
	Feb	.6	1.6	NA	13	15	1.0
	Mar	.6	1.4	NA	13	20	1.2
Calif: Los Angeles	Jan	1.1	1.4	5	9	15	.6
	Feb	.8	1.6	<5	5	20	.6
	Mar	.8	1.7	<5	4	10	.5
Colo: Denver	Jan	.7	1.2	<5	7	25	.5
	Feb	.6	1.3	<5	8	<5	.5
	Mar	.7	1.8	<5	8	15	.6
Del: Wilmington	Jan	.7	1.6	<5	10	15	.7
	Feb	.7	1.6	<5	9	25	.6
	Mar	.7	1.9	<5	10	20	.6
Fla: Tampa	Jan	.6	1.7	NA	10	35	1.0
	Feb	.6	1.6	NA	6	35	1.3
	Mar	.6	2.0	NA	8	40	1.3
Hawaii: Honolulu	Jan	.4	1.0	<5	3	25	.5
	Feb	.6	1.3	<5	4	20	.3
	Mar	.3	1.3	<5	3	20	.6
Idaho: Idaho Falls	Jan	1.0	1.8	<5	11	30	.5
	Feb	.7	2.0	<5	11	25	.5
	Mar	.9	1.9	<5	8	10	.5
Ill: Chicago	Jan	.7	1.7	<5	7	15	.7
	Feb	.8	1.6	<5	7	20	.8
	Mar	.8	1.8	<5	7	20	.5
Ky: Louisville	Jan	.7	1.8	NA	9	20	4.6
	Feb	.8	1.6	NA	10	15	1.2
	Mar	.7	1.6	NA	12	15	1.0
La: New Orleans	Jan	.7	1.8	<5	13	25	.9
	Feb	.6	1.5	<5	13	10	.8
	Mar	.7	1.7	<5	17	20	1.0
Mass: Boston	Jan	.7	1.8	<5	11	35	.7
	Feb	.8	1.6	<5	12	25	.4
	Mar	.7	1.4	<5	10	30	.5
Mo: St. Louis	Jan	.9	1.8	<5	10	20	.6
	Feb	.9	1.5	<5	11	15	1.0
	Mar	.9	1.6	<5	11	25	.6
Ohio: Cleveland	Jan	.8	1.7	<5	9	25	.5
	Feb	.6	2.0	<5	7	15	.6
	Mar	.7	1.8	<5	8	25	.6
Pa: Pittsburgh	Jan	.6	1.6	<5	8	25	.7
	Feb	.6	1.5	<5	8	20	.8
	Mar	.6	1.3	<5	7	25	.5
S. C: Charleston	Jan	.6	1.4	<5	13	25	1.2
	Feb	.7	1.4	<5	15	25	1.1
	Mar	.6	1.3	<5	12	20	2.9
S. Dak: Sioux Falls	Jan	.7	1.6	<5	5	20	.8
	Feb	.7	1.6	<5	6	25	.7
	Mar	1.2	1.6	<5	17	20	1.5
Tex: Austin	Jan	.6	1.5	NA	8	15	1.2
	Feb	.4	1.0	NA	6	5	1.0
	Mar	.6	1.4	NA	5	10	1.2
Vt: Burlington	Jan	.7	2.0	<5	13	30	.9
	Feb	.7	1.9	<5	12	20	.5
	Mar	.9	1.5	<5	11	30	.5
Wash: Seattle	Jan	.7	2.3	<5	8	45	.6
	Feb	.8	1.2	<5	10	20	.4
	Mar	.6	1.7	5	6	10	.6
Institutional average	Jan	0.7	1.6	<5	9	25	0.9
	Feb	.7	1.5	<5	9	20	.7
	Mar	.7	1.6	<5	9	20	.8

* Since iodine-131 and barium-130 were not detectable at most stations during the first quarter 1966, no provision was made for these nuclides in the table. The few exceptions are as follows: Iodine-131 was reported in January for New Orleans, 20 pCi/kg; and Phoenix, 23 pCi/kg. Barium-140 was reported for Palmer, Alaska, 17 pCi/kg; Denver, 12 pCi/kg; and Seattle, 31 pCi/kg. Barium-140 was also reported in February and March for Honolulu, 13 pCi/kg; and in March for Seattle, 11 pCi/kg.

NA, no analysis.

dietary intakes, "less than" 5 pCi/kg of strontium-89 was interpreted as 2.5 pCi/kg. The average food consumption rate during this period was 1.75 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (4).

Strontium-90 dietary intake during this

period averaged 16 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (FRC) (5). Cesium-137 intakes average 35 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9 to 12 years of age), October-December 1966

Location of institution	Month 1967	Total weight (kg/day)	Stable element intake (g/day)		Radionuclide intake (pCi/day)			
			Calcium	Potassium	⁹⁰ Sr	⁹⁰ Sr	¹³⁷ Cs	²²⁶ Ra
Alaska: Palmer.....	Jan	1.83	0.7	2.0	5	15	35	0.7
	Feb	1.75	1.2	1.9	5	23	45	1.4
	Mar	1.56	1.5	2.2	10	20	70	.9
Ariz: Phoenix.....	Jan	1.52	1.1	1.7	5	10	15	1.0
	Feb	2.03	1.2	2.2	5	10	5	1.2
	Mar	2.21	1.1	3.8	5	7	5	.9
Ark: Little Rock.....	Jan	1.19	.8	2.0	-----	15	25	1.0
	Feb	1.14	.7	1.8	-----	15	15	1.1
	Mar	1.28	.7	1.8	-----	17	25	1.5
Calif: Los Angeles.....	Jan	2.18	2.4	3.1	10	11	35	1.3
	Feb	2.09	1.7	3.3	5	10	40	1.3
	Mar	1.97	1.6	3.3	5	8	20	1.0
Colo: Denver.....	Jan	2.17	1.5	2.6	5	15	55	1.1
	Feb	2.06	1.2	2.7	5	16	5	1.0
	Mar	2.04	1.4	3.7	5	16	30	1.2
Del: Wilmington.....	Jan	2.17	1.5	3.9	5	22	35	1.5
	Feb	2.23	1.6	4.0	5	20	55	1.3
	Mar	2.05	1.4	3.9	5	21	40	1.2
Fla: Tampa.....	Jan	2.18	1.3	3.7	-----	20	75	2.2
	Feb	2.14	1.3	3.4	-----	13	75	2.6
	Mar	2.07	1.2	4.1	-----	17	85	2.7
Hawaii: Honolulu.....	Jan ^a	2.09	.8	2.1	5	6	50	1.0
	Feb ^b	1.95	1.0	2.5	5	8	40	.6
	Mar	2.16	.6	2.8	5	6	45	1.3
Idaho: Idaho Falls.....	Jan ^a	2.16	2.2	3.9	5	24	65	1.1
	Feb ^b	1.75	1.2	3.5	5	19	45	.8
	Mar ^a	2.09	1.9	4.0	5	17	20	1.0
Ill: Chicago.....	Jan ^a	1.53	1.1	2.6	5	11	25	1.1
	Feb	1.55	1.2	2.5	5	11	30	1.2
	Mar	1.73	1.4	3.1	5	12	35	.9
Ky: Louisville.....	Jan	1.24	.9	2.2	-----	11	25	5.7
	Feb	1.78	1.4	2.8	-----	18	25	2.1
	Mar ^b	1.68	1.2	2.7	-----	20	25	1.7
La: New Orleans.....	Jan	1.42	1.0	2.6	5	18	35	1.3
	Feb	1.68	1.0	2.5	5	22	15	1.3
	Mar	1.92	1.3	3.3	5	33	40	1.9
Mass: Boston.....	Jan	1.86	1.3	3.3	5	20	65	.7
	Feb	1.48	1.2	2.4	5	18	35	.7
	Mar	1.66	1.2	2.3	5	17	50	.7
Mo: St. Louis.....	Jan	1.43	1.3	2.6	5	14	30	.9
	Feb	1.38	1.2	2.1	5	15	20	1.4
	Mar	1.52	1.4	2.4	5	17	40	.9
Ohio: Cleveland.....	Jan	1.11	.9	1.9	5	10	30	.9
	Feb	1.37	.8	2.7	5	10	20	.8
	Mar ^b	1.41	1.0	2.5	5	11	35	.8
Pa: Pittsburgh.....	Jan	2.06	1.2	3.3	5	16	50	1.4
	Feb	2.17	1.3	3.3	5	17	40	1.7
	Mar	2.25	1.4	2.9	5	16	55	1.1
S. C: Charleston.....	Jan	1.62	1.0	2.3	5	21	40	1.9
	Feb	2.13	1.5	3.0	5	32	55	2.3
	Mar	1.43	.9	1.9	5	17	30	1.0
S. Dak: Sioux Falls.....	Jan ^a	1.21	.8	1.9	5	6	25	1.0
	Feb	1.20	.8	1.9	5	7	30	.8
	Mar ^a	1.11	1.3	1.8	5	19	20	1.7
Tex: Austin.....	Jan	1.66	1.0	2.5	-----	13	25	2.0
	Feb	1.56	.6	1.6	-----	9	10	1.6
	Mar	1.76	1.1	2.5	-----	9	20	2.1
Vt: Burlington.....	Jan	1.33	.9	2.7	5	17	40	1.2
	Feb ^a	1.30	.9	2.5	5	16	25	.6
	Mar	1.19	1.1	1.9	5	13	35	.6
Wash: Seattle.....	Jan ^a	1.94	1.4	2.5	5	16	85	1.2
	Feb ^a	1.72	1.4	2.1	5	17	35	.7
	Mar ^a	1.67	1.0	2.8	10	10	15	1.0
Institutional average.....	Jan	1.69	1.2	2.6	5	16	40	1.6
	Feb	1.75	1.2	2.6	5	16	30	1.4
	Mar	1.80	1.2	2.9	5	15	40	1.4

^a Since food samples were collected from two or more children who were over 12 years of age, data for this month were not used in institutional average.
^b Since food samples were collected from two or more children whose ages were unknown, data for this month were not used in institutional average.
^c Since food samples were collected from two or more children who were less than 9 years of age, data for this month were not used in the institutional average.

Annual averages

Annual average radionuclide concentrations in 1966 institutional total diet samples are given in table 3. The corresponding annual average intakes are presented in table 4. During 1966 the annual average intake varied from

1.27 to 2.41 kg/day with a mean of 1.79 kg/day. The average intake for 1965 was 1.89 kg/day (4) and for the period 1961-1964, 1.90 kg/day (5). The lower value for 1966 is due to the fact that the earlier data were not limited to the intake of children 9-12 years of

Table 3. 1966 annual average concentrations of selected stable elements and radionuclides in institutional daily diets of school children *

Location of institution	Stable element (g/kg)		Radionuclide concentration (pCi/liter)			
	Calcium	Potassium	⁹⁰ Sr	⁹⁰ Sr	¹³⁷ Cs	²²⁶ Ra
Alaska: Palmer.....	0.7	1.2	5	19	45	1.0
Ariz: Phoenix.....	.6	1.1	5	9	20	0.9
Ark: Little Rock.....	.6	1.5	5	15	20	1.1
Calif: Los Angeles.....	.9	1.4	5	8	20	1.4
Colo: Denver.....	.8	1.3	5	10	20	.7
Del: Wilmington.....	.7	1.6	5	10	30	.7
Fla: Tampa.....	.6	1.6	5	11	65	1.8
Hawaii: Honolulu.....	.5	1.2	5	4	30	.6
Idaho: Idaho Falls.....	.9	1.5	5	11	30	.6
Ill: Chicago.....	.7	1.6	5	8	30	.6
Ky: Louisville.....	.8	1.7	5	13	25	1.7
La: New Orleans.....	.7	1.6	5	17	30	.9
Mass: Boston.....	.6	1.5	5	9	30	.6
Mo: St. Louis.....	.8	1.6	5	11	30	.6
Ohio: Cleveland.....	.6	1.7	5	8	35	.7
Pa: Pittsburgh.....	.6	1.4	5	10	25	.7
S.C: Charleston.....	.7	1.4	5	14	35	1.3
S. Dak: Sioux Falls.....	.8	1.6	5	12	45	.7
Tex: Austin.....	.5	1.2	5	7	15	1.3
Vt: Burlington.....	.6	1.6	5	12	40	.6
Wash: Seattle.....	.8	1.5	5	16	45	.6
Institutional average.....	0.7	1.5	5	11	30	0.9

* Since iodine-131 and barium-140 concentrations were not detectable at most stations during the year 1966, no provision was made for these nuclides in the table. The few exceptions are:
 June 1966: 24 pCi/kg of iodine-131 was reported for Sioux Falls, S. Dak.
 October 1966: 10 pCi/kg of iodine-131 was reported for Louisville, Ky.
 December 1966: 10 pCi/kg of iodine-131 was reported for Phoenix, Ariz.; Palmer, Alaska; Tampa, Fla; and New Orleans, La.
 December 1966: Barium-140 was reported in the following institutions; Palmer, Alaska, 13 pCi/kg; Los Angeles, Calif., 16 pCi/kg; and Austin, Tex., 12 pCi/kg.

Table 4. 1966 annual average intakes of selected stable elements and radionuclides in institutional daily diets of school children (9-12 years of age)

Location of institution	Total weight (kg/day)	Stable element (g/day)		Radionuclide concentrations (pCi/day)			
		Calcium	Potassium	⁹⁰ Sr	⁹⁰ Sr	¹³⁷ Cs	²²⁶ Ra
Alaska: Palmer *	1.66	1.1	2.1	5	32	75	1.5
Ariz: Phoenix *	1.90	1.2	2.2	5	17	35	1.9
Ark: Little Rock.....	1.54	0.9	2.3	5	23	30	1.7
Calif: Los Angeles *	1.99	1.7	2.8	5	15	40	2.8
Colo: Denver *	2.18	1.6	2.7	5	22	45	1.4
Del: Wilmington *	2.00	1.4	3.3	5	20	60	1.4
Fla: Tampa *	1.97	1.4	3.1	5	22	140	3.5
Hawaii: Honolulu *	2.05	1.0	2.5	5	10	65	1.1
Idaho: Idaho Falls *	1.38	1.0	2.0	5	10	40	0.9
Ill: Chicago *	1.30	1.2	2.3	5	17	40	2.4
Ky: Louisville *	1.76	1.3	2.8	5	32	60	1.2
La: New Orleans *	2.07	1.2	3.1	5	17	65	1.1
Mass: Boston *	2.41	1.8	3.8	5	26	80	1.7
Mo: St. Louis *	1.34	.9	2.2	5	11	50	.9
Ohio: Cleveland *	2.20	1.2	3.1	5	21	45	1.4
Pa: Pittsburgh *	1.58	1.0	2.2	5	22	55	2.1
S.C: Charleston *	1.69	1.3	2.5	5	20	70	2.1
S. Dak: Sioux Falls *	1.69	.9	2.1	5	12	25	2.1
Tex: Austin *	1.27	.8	2.0	5	15	55	.8
Vt: Burlington.....							
Wash: Seattle *							
Institutional average.....	1.79	1.2	2.6	5	19	55	1.6

* The averages for these stations were restricted to include data for only those months for which food samples were collected from children 9-12 years of age.
 * Diet samples were collected throughout the year from children other than 9-12 years of age.
 * At these institutions no total diet samples was collected during one or more months of the year.

age. During this period calcium intakes varied from 0.8 to 1.8 g/day, with a mean of 1.2 g/day. Potassium annual average intake ranged from 2.0 to 3.8 g/day with a mean of 2.6 g/day.

Annual average daily intakes of strontium-89 were less than 10 pCi/day at each station. During 1966 annual average strontium-90 intakes ranged from 10 to 32 pCi/day with a mean of 19 pCi/day. Half of the stations' annual averages fall in FRC Range I and half fall in Range II (6), indicating that quantitative surveillance and routine control are the recommended course of action.

Cesium-137 annual average intakes ranged from 25 to 140 pCi/day with a mean of 55 pCi/

day. At the same time radium-226 intakes averaged 1.6 pCi/day.

Detectable low levels of iodine-131 were seen at the Sioux Falls station in June, Louisville in October and Phoenix, Palmer, Tampa, and New Orleans in December. Also some detectable barium-140 activity was seen in Palmer, Los Angeles, and Austin.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-September 1966	April 1967
October-December 1966	July 1967

2. Estimated daily intake of radionuclides in California diets, September-December 1966, January-February 1967

*Bureau of Radiological Health
California State Department of Public Health*

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (7).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 2).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to be-

lieve that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, and stable calcium, strontium, and sodium.

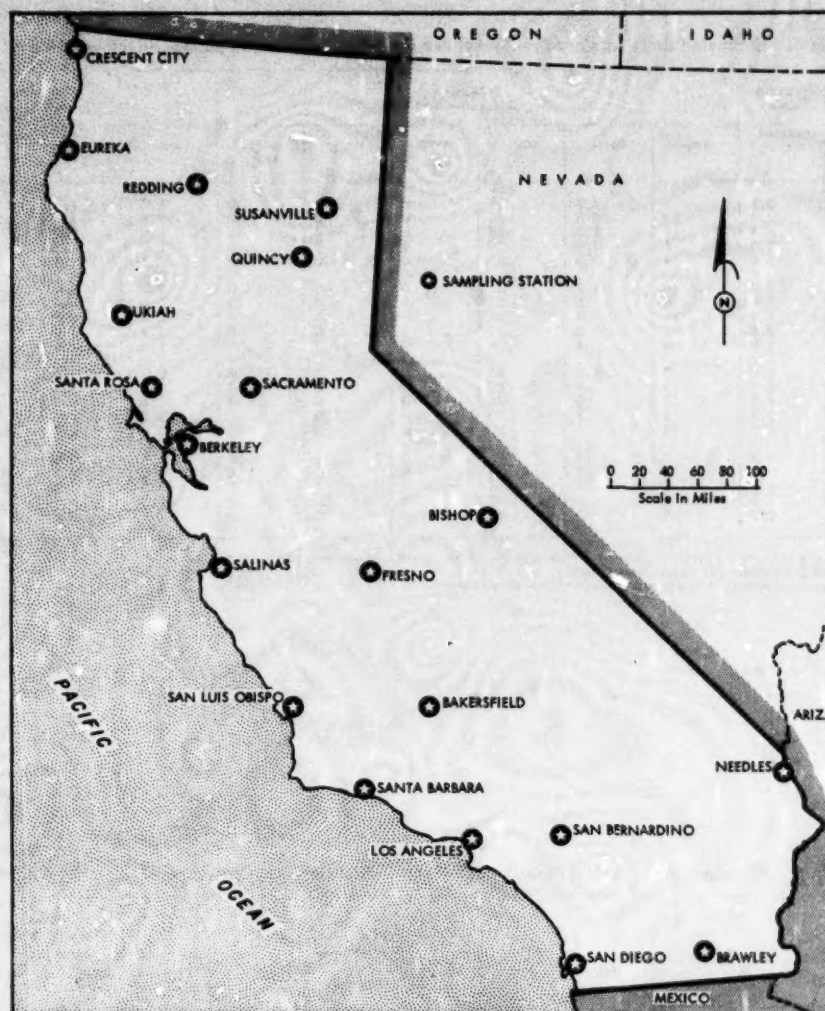


Figure 2. California diet sampling locations

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 5 (September–October 1966), table 6 (November–December 1966), and table 7 (January–February 1967).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. A summary of strontium-

90 and cesium-137 intake trends in California diets from January 1964 through February 1967 is given in figures 3 and 4.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–April 1966	January 1967
May–August 1966	May 1967

Table 5. Estimated daily intake of radionuclides in California diets, September-October 1966*

City	Consumption (kg/ capita·day) ^b	Intake (pCi/capita·day)						Intake (g/capita·day)			
		⁹⁰ Sr	²²⁶ Ra	¹³⁷ Cs	¹³² Sr	⁵⁴ Mn	¹³⁷ Cs ¹³⁴ Cs	K*	Na	Ca	Stable strontium
Bakersfield	2.1	5	1.3	16	0	0	0	2.6	3.3	0.9	0.002
Berkeley	2.3	10	1.2	36	0	0	0	2.5	3.4	.6	.001
Bishop	2.3	10	1.2	38	0	0	11	3.0	3.0	.9	.002
Brawley	1.7	6	1.0	19	4	0	0	2.0	2.7	.7	.002
Crescent City	1.9	12	0.9	28	0	0	0	2.1	4.1	.6	.002
Eureka	2.3	16	1.2	35	0	0	0	2.7	4.0	.9	.002
Fresno	1.9	6	.5	22	0	0	0	2.0	3.6	.6	.002
Los Angeles	2.4	11	1.4	35	0	0	0	3.0	4.1	1.6	.002
Needles	3.0	7	.8	22	0	0	0	2.8	2.9	.8	.002
Quincy	1.0	6	.4	16	0	0	0	1.3	1.4	.4	.001
Redding	1.9	7	1.2	21	0	0	0	1.3	2.9	.7	.001
Sacramento	2.7	10	1.1	27	0	0	0	3.0	5.5	1.2	.002
Salinas	2.3	8	.9	35	0	0	0	2.8	5.8	.7	.002
San Bernardino	1.8	4	.7	20	0	0	0	2.0	2.4	.6	.002
San Diego	2.3	13	1.3	28	0	0	0	2.9	2.4	.9	.002
San Luis Obispo	1.3	7	.7	11	0	0	0	1.8	2.4	.7	.002
Santa Barbara	2.3	7	.7	25	0	0	0	3.0	3.7	1.1	.002
Santa Rosa	2.3	6	.9	25	0	0	0	2.5	3.3	.9	.002
Susanville	1.9	7	.9	31	0	0	0	2.2	3.2	.7	.002
Ukiah	2.7	6	.5	21	0	0	0	2.7	3.6	1.1	.002

* Based on analyses of Hospital Standard Diets located in listed cities. Strontium-90 was not detectable.

^b Kilograms of food per person per day in this diet.

* Natural potassium contains 0.0119 percent of radioactive potassium-40.

Table 6. Estimated daily intake of radionuclides in California diets, November-December 1966*

City	Consumption (kg/ capita·day) ^b	Intake (pCi/capita·day)					Intake (g/capita·day)			
		⁹⁰ Sr	²²⁶ Ra	¹³⁷ Cs	¹³² Sr	⁵⁴ Mn	K*	Na	Ca	Stable strontium
Bakersfield	2.3	1	6	0.6	10	0	3.0	3.8	1.5	0.002
Berkeley	2.0	1	6	1.2	17	0	2.1	3.6	0.6	.002
Bishop	1.9	0	8	1.0	23	0	2.7	3.3	1.7	.004
Brawley	1.8	1	6	.8	18	0	2.5	3.7	.7	.004
Crescent City	2.2	9	11	.5	23	0	3.0	5.5	.7	.002
Eureka	2.2	4	12	.3	31	0	2.4	3.4	.8	.002
Fresno	2.4	1	5	1.6	23	0	2.6	3.8	.5	.002
Los Angeles	1.8	2	5	.3	27	42	1.4	2.7	1.0	.002
Needles	1.9	0	6	.6	18	0	2.0	3.4	.7	.002
Quincy	1.8	2	6	.5	20	0	3.7	4.0	.6	.002
Redding	NS									
Sacramento	2.6	0	6	2.0	15	4	3.9	4.5	1.4	.002
Salinas	NS									
San Bernardino	1.9	1	4	.9	23	0	2.4	3.4	.9	.002
San Diego	1.9	1	5	.5	15	0	2.5	2.0	.7	.002
San Luis Obispo	1.5	1	6	2.1	18	0	2.0	3.2	.7	.002
Santa Barbara	2.1	1	11	.7	19	4	2.5	3.6	1.1	.004
Santa Rosa	1.7	2	4	.5	18	0	1.8	2.9	.9	.002
Susanville	1.9	1	6	ND	18	0	2.7	4.5	.9	.002
Ukiah	2.6	1	10	1.0	21	43	3.0	5.3	1.3	.002

* Based on analyses of Hospital Standard Diets located in listed cities.

^b Kilograms of food per person per day in this diet.

* Natural potassium contains 0.0119 percent of radioactive potassium-40.

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate but is not statistically significant.

NS, no sample collected or analyzed.

ND, not detectable.

Table 7. Estimated daily intake of radionuclides in California diets, January-February 1967^a

City	Consumption (kg/capita-day) ^b	Intake (pCi/capita-day)							Intake (g/capita-day)			
		⁹⁰ Sr	¹³⁷ Sr	²²⁶ Ra	¹³⁷ Cs	⁹⁰ Zr	⁵⁴ Mn	¹⁴⁴ Ce ¹⁴⁶ Ce	K ⁴⁰	Na	Cs	Stable strontium
Bakersfield	2.1	0	5	0.5	0	1	0	0	2.5	3.9	1.1	0.003
Berkeley	2.1	1	6	1.3	34	0	0	0	2.6	4.3	0.8	.004
Bishop	2.3	0	10	1.4	15	0	0	0	2.8	4.8	1.6	.003
Brawley	1.8	2	6	.7	10	0	0	0	1.9	2.2	1.0	.002
Crescent City	2.2	7	12	.7	26	0	0	0	2.3	4.2	.8	.005
Eureka	2.2	41	8	1.0	23	0	0	0	2.3	3.8	1.1	.003
Fresno	2.4	1	5	1.8	29	0	0	0	2.5	3.6	.7	.005
Los Angeles	2.1	2	7	.8	23	6	0	7	2.6	4.1	.9	.004
Needles	2.3	1	8	.3	17	0	0	2	2.5	3.9	1.0	.005
Quincy	2.2	0	10	1.2	40	0	0	0	2.2	3.2	1.1	.003
Redding	2.2	0	8	.7	31	0	0	0	2.4	3.2	.9	.003
Sacramento	2.5	43	7	1.2	21	4	0	0	2.4	4.6	1.3	.004
Salinas	2.3	41	4	1.1	29	0	0	0	2.6	5.0	.7	.003
San Bernardino	2.3	41	9	1.0	7	0	0	0	3.2	4.1	1.2	.003
San Diego	2.0	41	7	1.0	27	0	0	0	2.4	3.0	.8	.004
San Luis Obispo	1.5	2	6	1.0	18	0	0	0	1.9	3.7	1.1	.003
Santa Barbara	2.2	1	5	.9	17	1	0	0	2.3	3.6	1.1	.003
Santa Rosa	2.0	42	7	1.3	14	1	0	0	2.2	3.6	1.0	.005
Susanville	1.9	42	4	.5	22	0	0	0	2.0	3.7	.8	.002
Ukiah	2.4	0	5	1.6	28	0	0	0	2.2	3.6	.9	.004

^a Based on analyses of Hospital Standard Diets located in listed cities.

^b Kilograms of food per person per day in this diet.

^c Natural potassium contains 0.0119 percent of radioactive potassium-40.

^d When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

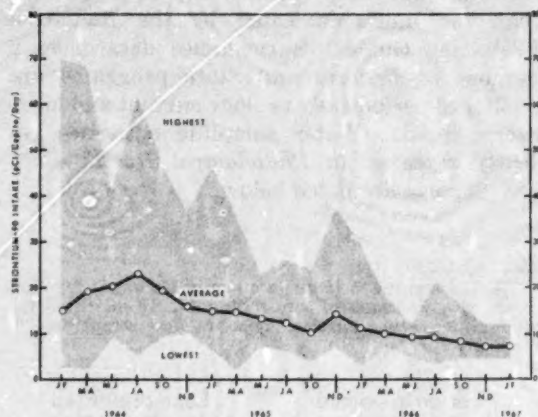


Figure 3. Averages and ranges of daily strontium-90 intake in California diets, 1964-February 1967

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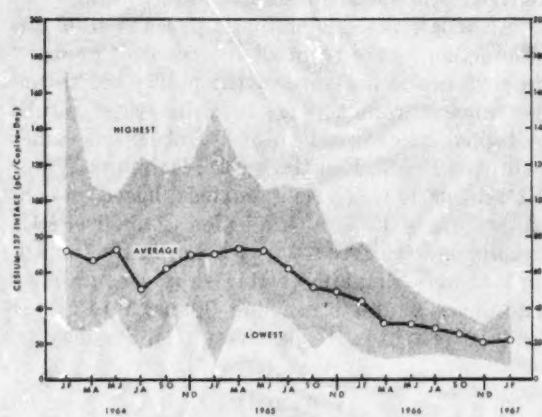


Figure 4. Averages and ranges of daily cesium-137 intake in California diets, 1964-February 1967

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be

set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analyses indicate that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Activity	Period reported	Last presented
California Water Sampling Program	January-June 1966	June 1967
Coast Guard Water Sampling Program	1965	November 1966
Minnesota Surface Water Sampling Program	January-June 1966	January 1967
New York Surface Water Sampling Program	June-December 1965	June 1966
Radiostromtium in Tap Water, HASL	March-November 1966	June 1967
Washington Surface Water Sampling Program	July 1965-June 1966	August 1967

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Gross Radioactivity in Surface Waters of the United States, April 1967

*Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior*

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the level which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in

raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (1-6). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These Arbitrary levels provide a basis for the selection of data and for additional comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assess-

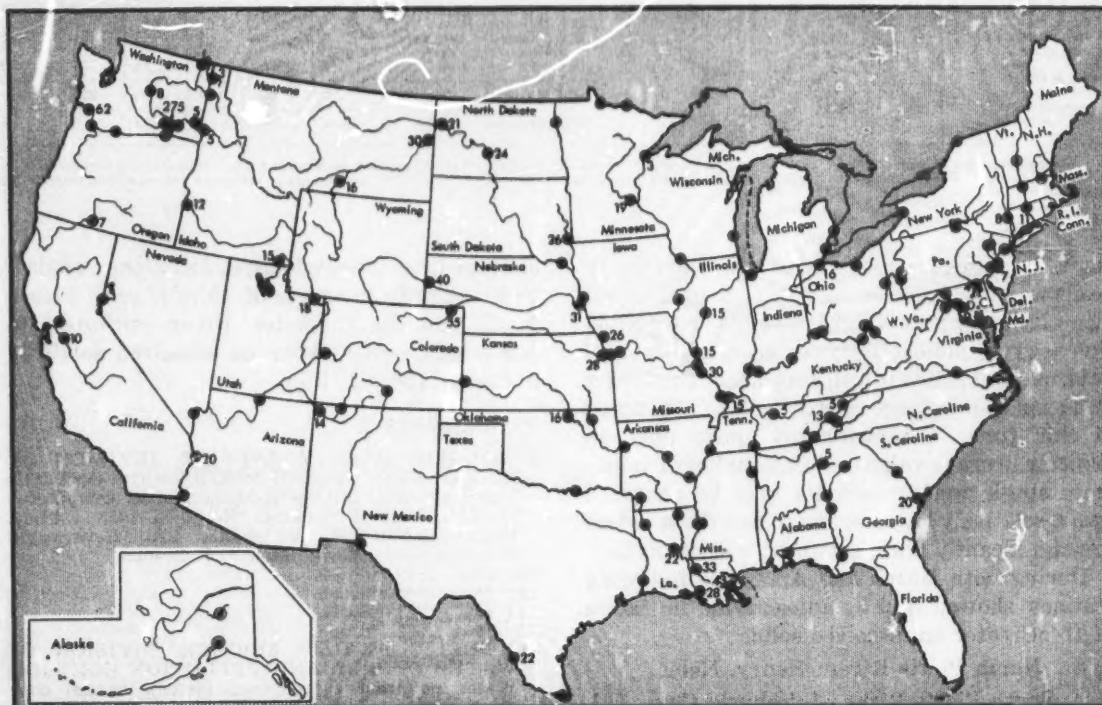


Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, April 1967

Table 1. Radioactivity in raw surface waters, April 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)			Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Sus-pended	Dis-solved	Total	Sus-pended	Dis-solved	Total		Sus-pended	Dis-solved	Total	Sus-pended	Dis-solved	Total
Arkansas River:							Mississippi River:						
Ponca City, Okla.	0	2	2	4	12	16	St. Paul, Minn.	0	2	2	2	17	19
Atchafalaya River:							E. St. Louis, Ill.	6	1	7	22	8	30
Morgan City, La.	7	1	8	21	7	28	New Roads, La.	2	2	4	11	23	33
Bear River:							New Orleans, La.	16	0	16	35	8	43
Fremont, Idaho.	0	1	1	1	14	15	Missouri River:						
Big Horn River:							Williston, N. Dak.	1	2	3	7	14	21
Hardin, Mont.	0	3	3	4	12	16	Bismarck, N. Dak.	3	2	5	11	18	24
Big Sioux River:							St. Joseph, Mo.	1	4	5	9	17	26
Sioux Falls, S. Dak.	1	4	5	6	20	26	North Platte River:						
Clearwater River:							Henry, Nebr.	< 1	30	30	4	36	40
Lewiston, Idaho.	< 1	0	< 1	2	3	5	Ohio River:						
Clinch River:							Cairo, Ill.	1	0	1	7	8	15
Clinton, Tenn.	0	0	0	1	4	5	Pend Oreille River:						
Kingston, Tenn.	0	< 1	< 1	1	12	13	Albani Falls Dam, Idaho.	0	1	1	< 1	3	3
Colorado River:							Platte River:						
Parker Dam, Calif.							Plattsmouth, Nebr.	3	7	10	10	21	31
Arlis.	0	6	6	0	20	20	Potomac River:						
Columbia River:							Washington, D.C.	0	1	1	1	5	6
Wenatchee, Wash.	0	2	2	1	7	8	Red River, South:						
Pasco, Wash.	0	1	1	42	233	275	Alexandria, La.	3	1	4	13	9	22
Clatskanie, Ore.	0	1	1	14	48	62	Rio Grande:						
Connecticut River:							Laredo, Tex.	3	3	6	10	12	22
Enfield Dam, Conn.	< 1	2	2	2	9	11	San Joaquin River:						
Coosa River:							Vernalis, Calif.	1	2	3	2	8	10
Rome, Ga.	< 1	< 1	< 1	1	4	5	San Juan River:						
Cumberland River:							Shiprock, N. Mex.	0	2	2	2	12	14
Cheatham Lock, Tenn.	0	0	0	1	4	5	Savannah River:						
Delaware River:							Port Wentworth, Ga.	0	0	0	2	18	20
Philadelphia, Pa.	0	0	0	2	5	7	Snake River:						
Great Lakes:							Payette, Idaho.	< 1	5	5	3	9	12
Duluth, Minn.	0	0	0	0	3	3	Wawawai, Wash.	0	1	1	1	4	5
Green River:							South Platte River:						
Dutch John, Utah.	0	5	5	1	17	18	Julesburg, Colo.	0	34	34	4	51	55
Hudson River:							Susquehanna River:						
Foughkeepsie, N.Y.	0	0	0	2	6	8	Conowingo, Md.	0	0	0	2	2	4
Illinois River:							Tennessee River:						
Peoria, Ill.	1	2	3	4	11	15	Chattanooga, Tenn.	0	1	1	0	4	4
Grafton, Ill.	0	1	1	2	13	15	Yellowstone River:						
Kansas River:							Sidney, Mont.	4	5	9	16	14	30
DeSota, Kans.	3	1	4	17	11	28	Maximum.	16	34	34	42	233	275
Klamath River:							Minimum.	0	0	0	0	2	3
Keno, Ore.	0	0	0	1	6	7							
Maumee River:													
Toledo, Ohio.	2	2	4	7	9	16							

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

ment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both March and April, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River; Henry, Nebr.

South Platte River; Julesburg, Colo.

During April, New Orleans, La., on the Mis-

issippi River showed suspended alpha radioactivity slightly in excess of 15 pCi/liter. Pasco, Wash., on the Columbia River continued to show beta radioactivity on dissolved solids in excess of 150 pCi/liter.

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Radioactivity in Minnesota Municipal Water Supplies, July-December 1966¹

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At

present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul and monthly at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250-ml sample of water is transferred to a 2-inch planchet and

¹ Data and information from "Survey of Environmental Radioactivity, July-December 1966," Publication No. COO-651-41. State of Minnesota Department of Public Health, University Campus, Minneapolis, Minn. 55440.

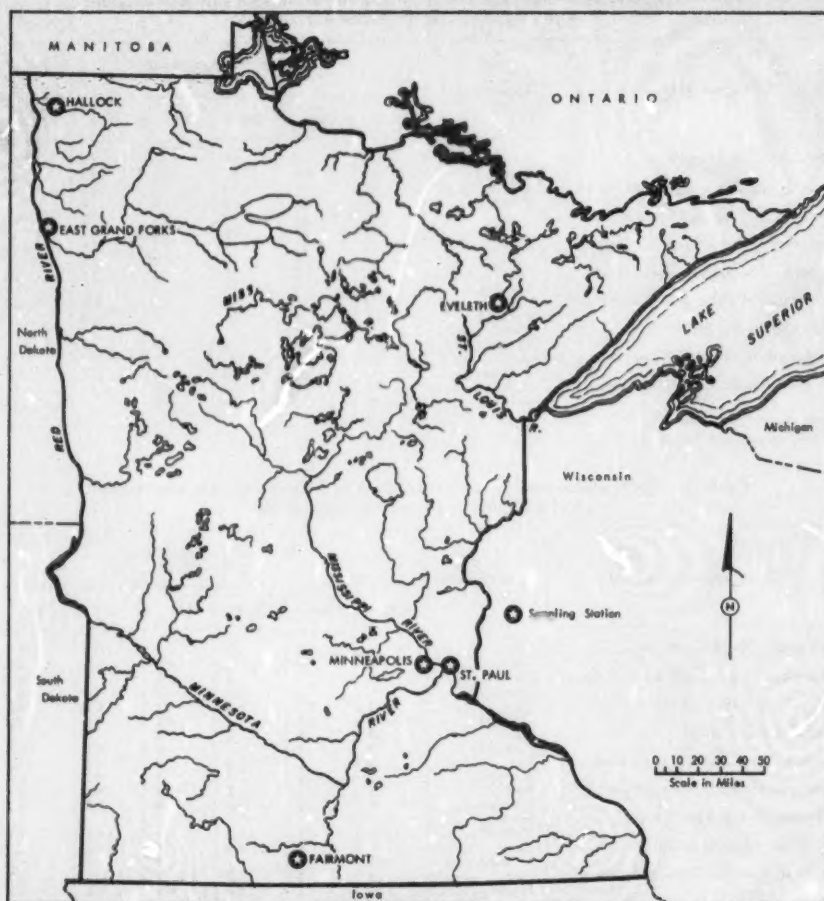


Figure 1. Minnesota surface water sampling locations

evaporated at 75° C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from July-December 1966. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha concentrations reported as <1 pCi/liter were considered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 4 to 26 pCi/liter, which is well below the Public Health Service Drinking Water Standards (1).

REFERENCE

- (1) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 1. Total beta-particle concentrations in Minnesota raw and treated water supplies, July-December 1966

Town and water source	Type of water	Average concentrations (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River.....	Raw.....	21	18	19	16	16	25
	Treated.....	26	22	21	19	22	19
East Grand Forks, Red Lake River.....	Raw.....	24	21	20	16	18	16
	Treated.....	12	13	11	8	9	9
Eveleth, St. Mary's Lake.....	Raw.....	13	13	13	11	12	12
	Treated.....	14	14	16	12	12	12
Fairmount, Budd Lake.....	Raw.....	15	14	15	14	11	17
	Treated.....	8	6	9	8	11	6
Halleck, Two Rivers, South Fork.....	Raw.....	18	17	21	17	18	4
	Treated.....	12	10	7	7	7	7
International Falls, Rainy River.....	Raw.....	9	11	9	7	NS	9
	Treated.....	14	9	11	9	NS	8
Minneapolis tap water.....	Raw.....	8	7	6	7	4	4
	Treated.....	15	12	10	7	9	9
St. Cloud, Mississippi River.....	Raw.....	5	5	10	5	5	4
	Treated.....	12	14	14	12	11	12
St. Paul, Vadnais Chain of Lakes.....	Raw.....	9	7	8	8	8	5

NS, no samples collected.

Table 2. Total alpha-particle concentrations in Minnesota raw and treated water supplies, July-December 1966

Town and water source	Type of water	Average concentrations (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River.....	Raw.....	4	1	3	1	<2	<2
	Treated.....	3	3	2	<1	<2	<2
East Grand Forks, Red Lake River.....	Raw.....	4	3	1	1	1	<2
	Treated.....	1	3	<1	<1	<2	<2
Eveleth, St. Mary's Lake.....	Raw.....	<1	<1	<1	<1	<1	<1
	Treated.....	1	<1	1	<1	<1	<2
Fairmount, Budd Lake.....	Raw.....	11	6	7	8	6	3
	Treated.....	2	2	1	2	<1	<1
Halleck, Two Rivers, South Fork.....	Raw.....	2	1	2	2	<3	<3
	Treated.....	2	1	1	1	<2	<3
International Falls, Rainy River.....	Raw.....	1	<1	1	1	NS	<1
	Treated.....	1	1	1	2	NS	<1
Minneapolis tap water.....	Raw.....	1	1	<1	<1	<1	<1
	Treated.....	1	1	<1	1	<2	<2
St. Cloud, Mississippi River.....	Raw.....	<1	1	<1	1	<1	<2
	Treated.....	<1	1	2	1	<1	<2
St. Paul, Vadnais Chain of Lakes.....	Raw.....	1	1	<1	<1	<1	<2
	Treated.....	1	1	1	1	<1	<2

NS, no sample collected.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, the surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of

atmospheric radioactivity in the Western Hemisphere. These include data from the programs of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above programs was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

<u>Network</u>	<u>Period</u>	<u>Issue</u>
HASL Fallout Network	July-December 1966	September 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	January-March 1967	September 1967

1. Radiation Surveillance Network June 1967

*National Center for Radiological Health and
National Center for Urban and Industrial
Health, PHS*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity

made by the station operators. These estimates are made after the decay of radon and thoron daughter products and prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (1). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during June 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Air and precipitation samples were generally near or below detectable levels. The only elevation in air radioactivity occurred at Agana, Guam, on June 21 and 22, when the levels found were 0.80 pCi/m³ and 0.58 pCi/m³, respectively. Fresh fission products were identified by



Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1967

Station location		Number of samples		Air surveillance, gross beta radioactivity (pCi/m ³)			Last profile in RHD&R	Precipitation	
		Air	Pptn	Maximum	Minimum	Average *		Total depth (mm)	Total deposition (nCi/m ²)
Ala:	Montgomery	30	7	0.06	0.01	0.03	Nov 66	136	<27
Alaska:	Adak	29		.04	.00	.01	June 67	(b)	
	Anchorage	24	10	.03	.00	.01	Dec 66	37	< 8
	Atu Island	26		.02	.00	.01	July 67	(b)	
	Fairbanks	(*)					Jan 67	(b)	
	Juneau	24	8	.05	.00	.02	Apr 67	126	<28
	Kodiak	5		.02	.00	.01	May 67	(b)	
	Nome	(*)					Sept 67	(b)	
	Pt. Barrow	30		.02	.00	.00	Aug 67	(b)	
	St. Paul Island	(*)					Oct 67	(b)	
Aris:	Phoenix	30		.10	.02	.05	Apr 67	(b)	
Ark:	Little Rock	29	6	.07	.01	.03	Dec 66	86	<17
Calif:	Berkeley	24	3	.06	.00	.02	May 67	33	< 7
	Los Angeles	24		.04	.01	.03	Sept 67	(b)	
C. Z:	Ancon	20		.03	.00	.01	May 67	(b)	
Colo:	Denver	29	12	.08	.01	.04	May 67	113	<23
Conn:	Hartford	29	7	.09	.01	.04	Apr 67	62	<13
Del:	Dover	24		.06	.01	.04	Nov 66	(b)	
D. C:	Washington	30	3	.06	.02	.04	Aug 67	41	< 8
Fla:	Jacksonville	30	16	.06	.00	.02	Dec 66	242	<48
	Miami	30	12	.04	.01	.02	Apr 67	168	<34
Gas:	Atlanta	30	9	.06	.01	.03	Oct 67	139	<28
Guam:	Agana	30		.80	.00	.06	Nov 66	(b)	
Hawaii:	Honolulu	30		.05	.00	.02	July 67	(b)	
Idaho:	Boise	28		.21	.02	.05	July 67	32	< 7
Ill:	Springfield	29	9	.08	.02	.04	Aug 67	70	<14
Ind:	Indianapolis	30	3	.08	.02	.04	Oct 67	16	< 3
Iowa:	Iowa City	30	8	.09	.01	.04	May 67	196	<39
Kans:	Topeka	29	2	.09	.00	.03	Dec 66	37	< 7
Ky:	Frankfort	29	8	.08	.01	.04	Aug 67	46	< 9
La:	New Orleans	30	9	.05	.01	.02	Aug 67	165	<33
Maine:	Augusta	30	9	.08	.00	.05	Sept 67	236	<47
Md:	Presque Isle	17	3	.10	.00	.05	May 67	28	< 6
	Baltimore	23	2	.08	.02	.05	Apr 67	15	< 3
Mass:	Lawrence	19	2	.07	.02	.04	July 67	44	< 9
	Winchester	28	8	.10	.00	.06	Nov 66	116	<23
Mich:	Lansing	17	8	.07	.00	.04	June 67	49	<10
Minn:	Minneapolis	29	12	.08	.02	.04	July 67	149	<30
Miss:	Jackson	23	14	.06	.00	.03	Nov 66	188	<40
Mo:	Jefferson City	30	4	.05	.01	.02	Sept 67	68	<14
			11	.07	.01	.03	Oct 67	170	<34
Mont:	Helena	30	13	.11	.01	.05	June 67	56	<12
Nebr:	Lincoln	18	11	.12	.01	.04	Oct 67	365	<73
Nev:	Las Vegas	29		.08	.01	.04	Jan 67	(b)	
N. H:	Concord	23		.09	.01	.06	Aug 67	(b)	
N. J:	Trenton	29	3	.07	.01	.04	Sept 67	16	< 3
N. Mex:	Santa Fe	29	5	.06	.01	.03	June 67	27	< 6
N. Y:	Albany	24	4	.08	.01	.05	Oct 67	51	<10
	Buffalo	29		.08	.02	.05	May 67	(b)	
	New York City	30		.08	.01	.04	June 67	(b)	
N. C:	Gastonia	30	8	.08	.01	.04	May 67	121	<24
N. Dak:	Bismarck	30	8	.09	.01	.05	Aug 67	22	< 4
Ohio:	Cincinnati	17		.07	.02	.04	Nov 66	(b)	
	Columbus	30	2	.12	.03	.07	Sept 67	33	< 7
	Painesville	29	6	.08	.02	.05	Apr 67	51	<10
Okla:	Oklahoma City	30	6	.05	.01	.02	July 67	64	<13
	Ponca City	24	10	.03	.00	.01	Apr 67	244	<49
Ore:	Portland	29	5	.07	.00	.03	Oct 67	22	< 4
Pa:	Harrisburg	30		.10	.01	.04	Sept 67	(b)	
P. R:	San Juan	29	7	.08	.02	.04	Oct 67	131	<26
R. I:	Providence	30	8	.06	.00	.03	July 67	60	<12
S. C:	Columbia	25	6	.05	.01	.03	June 67	81	<16
S. Dak:	Pierre	29	6	.08	.02	.04	Apr 67	154	<31
Tenn:	Nashville	29	8	.06	.01	.03	July 67	100	<20
Tex:	Austin	30		.07	.01	.03	Nov 66	(b)	
	El Paso	28	5	.06	.01	.03	Aug 67	16	< 3
Utah:	Salt Lake City	28	14	.09	.01	.05	Sept 67	62	<12
Vt:	Barre	27	8	.10	.01	.05	Dec 66	53	<11
Va:	Richmond	29	4	.07	.01	.04	Dec 66	50	<10
Wash:	Seattle	30	2	.06	.00	.02	Dec 66	25	< 5
	Spokane	30	2	.11	.01	.04	Nov 66	38	< 8
W. Va:	Charleston	30	6	.07	.01	.04	June 67	43	< 9
Wis:	Madison	29	12	.60	.01	.05	Dec 66	152	<31
Wyo:	Cheyenne	30	13	.15	.00	.04	Jan 67	72	<14
Network summary		1,931	394	0.80	0.00	0.03		91	<18

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
 (b) No precipitation sample collected.
 (c) No report received.

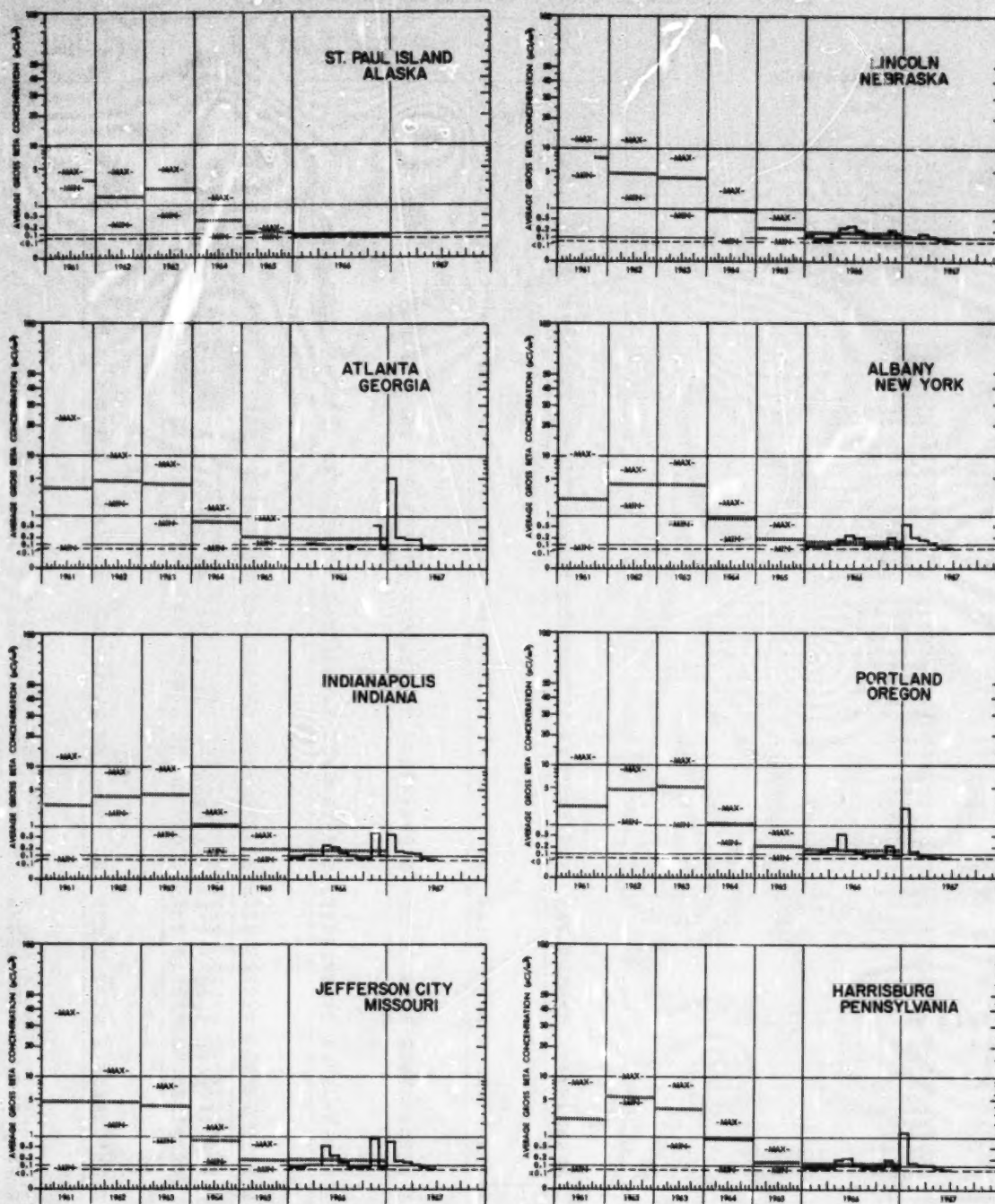


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1961–June 1967

gamma-ray spectroscopy on the June 21 sample. The one precipitation sample more active than the minimum reporting level of 200 pCi/liter was collected at Minneapolis, Minn., on June 29 and contained 2.9 nCi/m² of gross beta radio-

activity. Fission products were identified on this sample but decay data indicates that the radioactive material was more than 100 days old.

2. Canadian Air and Precipitation Monitoring Program, June 1967¹

*Radiation Protection Division
Department of National Health and Welfare*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations

are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (2-6).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for June 1967 are presented in table 2.

¹ Prepared from information and data in the July 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.



Figure 3. Canadian air and precipitation sampling stations

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations pCi/liter	Total deposition (nCi/m ²)
Calgary.....	30	0.1	0.0	0.0	11	1.0
Coral Harbour.....	27	.0	.0	.0	22	.8
Edmonton.....	30	.1	.0	.0	10	.6
Ft. Churchill.....	30	.1	.0	.0	6	.7
Ft. William.....	30	.1	.0	.0	19	1.7
Fredericton.....	30	.1	.0	.0	6	.6
Goose Bay.....	30	.1	.0	.0	45	2.4
Halifax.....	30	.1	.0	.0	15	.7
Inuvik.....	30	.1	.0	.0	25	.8
Montreal.....	30	.1	.0	.0	11	1.4
Moosonee.....	30	.1	.0	.0	21	.6
Ottawa.....	30	.1	.0	.0	15	1.7
Quebec.....	30	.1	.0	.0	10	1.5
Regina.....	29	.1	.0	.0	44	1.3
Resolute.....	29	.0	.0	.0	NS	NS
St. John's, Nfld.....	30	.1	.0	.0	20	.4
Saskatoon.....	30	.1	.0	.0	22	1.2
Sault Ste. Marie.....	30	.1	.0	.0	18	1.4
Toronto.....	30	.1	.0	.0	9	1.2
Vancouver.....	30	.1	.0	.0	42	.5
Whitehorse.....	30	.1	.0	.0	90	.6
Windsor.....	30	.1	.0	.0	14	1.3
Winnipeg.....	30	.1	.0	.0	27	1.4
Yellowknife.....	28	.1	.0	.0	38	.8
Network summary	30	0.1	0.0	0.0	24	1.1

NS, no sample collected.

3. Mexican Air Monitoring Program June 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada.

Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the

Table 4. Mexican gross beta radioactivity of airborne particulates, June 1967

Station	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average
Acapulco.....	3	0.1	0.1	0.1
Chihuahua.....	5	.1	.1	.1
Ciudad Juárez.....	7	.1	< .1	< .1
Ensenada.....	7	.1	< .1	< .1
Guadalajara.....	4	.1	.1	.1
Guaymas.....	NS			
La Paz.....	6	.1	.1	.1
Matamoros.....	NS			
Massatlán.....	4	.1	.1	.1
Mérida.....	9	.3	< .1	.1
México, D.F.....	3	.1	.1	.1
Nuevo Laredo.....	NS			
San Luis Potosí.....	NS			
Tampico.....	NS			
Torreón.....	4	.1	< .1	< .1
Veracruz.....	1	.1	.1	.1

NS, no sample collected, station temporarily shutdown.

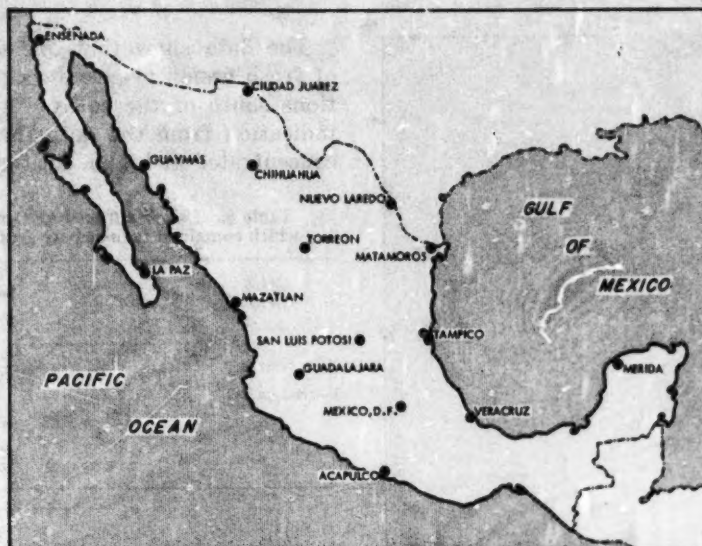


Figure 4. Mexican air sampling locations

Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the

Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta-particle concentrations in surface air during June 1967 are presented in table 4.

4. Pan American Air Sampling Program June 1967

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided

by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling sites are shown in figure 5.

The June 1967 air monitoring results from the participating countries are given in table 5. Increases in airborne gross beta radioactivity occurred in all reporting stations south of the equator. Those samples more active than 1.0 pCi/m³ at the time of collection are presented in table 6.

Fresh fission products were identified by gamma-ray spectroscopy on 14 samples including those containing radioactivity greater than



Figure 5. Pan American Air Sampling Program stations

Table 5. PAHO gross beta radioactivity in surface air June 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average *
Argentina, Buenos Aires	19	0.62	0.01	0.09
Bolivia, La Paz	19	17.50	.01	1.91
Chile, Santiago	30	.48	.01	.09
Colombia, Bogotá	19	.01	.00	.00
Ecuador, Guayaquil	1	.18	.18	.18
Jamaica, Kingston	17	.05	.01	.03
Peru, Lima	25	1.67	.00	.25
Venezuela, Caracas	18	.03	.00	.01
West Indies, Trinidad	30	.04	.00	.02
Pan American summary	168	17.50	0.00	0.28

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

1.0 pCi/m³. Other samples which had probably been more radioactive than 1.0 pCi/m³ at collection, were not received until 3 to 4 weeks after collection and while still containing more radioactivity than normal levels, had decayed sufficiently so that decay calculations and gamma-ray spectroscopy were not feasible.

The data show that one or two intrusions of fresh fission products occurred at those stations south of the equator and there is some indication from the data that the debris was concentrated at higher altitudes.

Table 6. Samples from PAHO member countries which contained radioactivity greater than 1 pCi/m³

Location	Date	Gross beta radioactivity at collection (pCi/m ³)
Peru: Lima	June 20	1.04
	23	1.67
Bolivia: La Paz	June 14	1.04
	15	17.50
	16	11.05
	17-20	2.90
	22-23	3.10
	24-26	1.28

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in previous sections. Included are such data as those obtained from

human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational

Safety in directives published in the "AEC Manual."¹

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, Knolls Atomic Power Laboratory, and the S1C Prototype Reactor Facility.

¹ Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Bettis Atomic Power Laboratory July-December 1966^{*}

*Westinghouse Electric Corporation
Pittsburgh, Pennsylvania*

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pa. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

^{*} Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the Second 6 Months of 1966" (PNR-SMD-140).

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma radioactivity, and quarterly for strontium-90 radioactivity.

The average concentration of gross beta radioactivity in the main laboratory liquid effluent during this period was 5.5×10^2 pCi/liter. This was higher than the average concentration of 1.5×10^2 pCi/liter observed for the first 6 months of 1966. The maximum and minimum gross beta radioactivity detected in the weekly samples amounted to concentrations of 1,800 pCi/liter and 35 pCi/liter, respectively.

The average concentration of gross alpha particle activity in the main laboratory effluent was 5.6 pCi/liter; a reduction from the 7.4 pCi/liter average for the previous 6-month period.

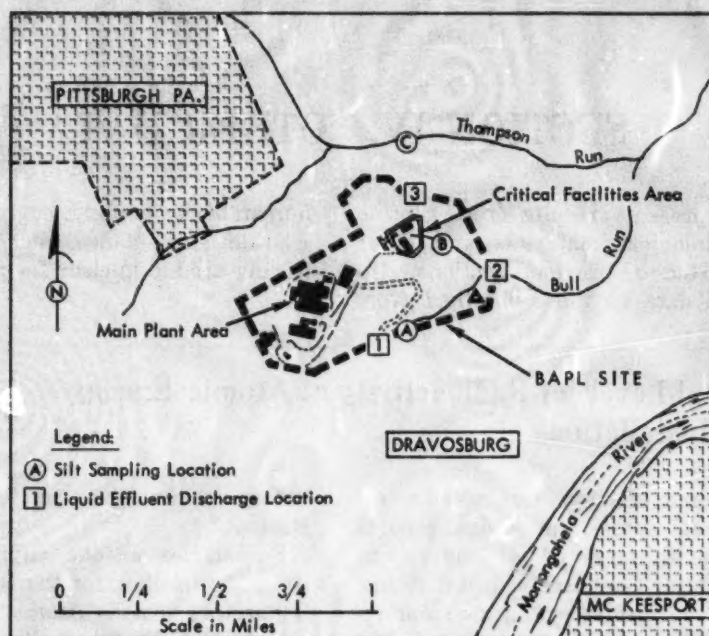


Figure 1. Bettis Atomic Power Laboratory sampling stations

The maximum gross alpha particle radioactivity detected in weekly samples during this period was 19 pCi/liter while the minimum concentration was 1.0 pCi/liter.

The average concentration of strontium-90 in liquid waste was 42 pCi/liter as compared with 3.9 pCi/liter for the first 6 months of 1966.

Average radioactivity in liquid waste effluent from the critical facility operations during the second half of 1966 were: alpha radioactivity— 1.3×10^2 pCi/liter, beta-gamma radioactivity— 5.2×10^3 pCi/liter. Comparable values for the first 6 months in 1966 were <68 pCi/liter for alpha radioactivity and 1.3×10^3 pCi/liter for beta-gamma radioactivity.

Background monitoring stations

Beta-gamma background radiation levels were continuously monitored and recorded at 34 film badge monitoring stations located at 100-yard intervals along the boundary of the laboratory property which lies within the con-

trolled confines of the Bettis Atomic Power Laboratory site.

The average beta-gamma background radiation level during the fourth quarter of 1966 was 0.051 mR/hr for the main laboratory area and 0.010 mR/hr for the critical facility area. The respective average exposure values for the previous period from January 1 through June 30, 1966, were 0.067 mR/hr and 0.028 mR/hr. Table 1 summarizes results obtained during the second half of 1966 from the background monitoring stations.

Table 1. Beta-gamma background radiation monitoring Bettis, October–December 1966*

Location	Exposure levels (mR/hr)	
Main laboratory area (20 locations).....	Maximum	0.358
	Minimum	.018
	Average	.051
Critical facility area (14 locations).....	Maximum	.026
	Minimum	< .004
	Average	.010
All locations.....	Average	.030

* Third quarter results were considered invalid and questionable, therefore, only the fourth quarter results were used to determine the average levels for the second half of 1966.

Stream silt

Stream silt samples were collected quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2. The average alpha and beta-gamma radioactivity concentrations of stream silt samples were 0.83 pCi/g and 14 pCi/g, respectively, for the second half of 1966. The average alpha-particle concentration was higher than the concentration of 0.65 pCi/g for the first 6 months of 1966. The average beta-

Table 2. Radioactivity in stream silt, Bettis July-December 1966

Period 1966	Location *	Radioactivity concentration (pCi/g)	
		Alpha	Beta-gamma
July-September	A	0.91	5.2
	B	1.3	1.6
	C	.2	1.1
	Average	.4	2.6
October-December	A	.40	58
	B	.20	11
	C	.15	6.8
	Average	.25	25
Second half	Average	.82	14

* Refer to figure 1 for locations.

gamma concentration was lower than the concentration of 22 pCi/g for the first 6 months of 1966.

Semiannual analyses for strontium-89 and strontium-90 were obtained for composites of quarterly silt samples. Table 3 presents the results of these analyses for samples collected during the first 6 months of 1966.

Table 3. Strontium-89 and strontium-90 in stream silt (6-month composite) Bettis, January-June 1966

Location *	Concentration (pCi/g of silt)	
	Strontium-89	Strontium-90
A	0.090	0.22
B	.081	.05
C	.027	.072

* See figure 1 for locations.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-December 1965	October 1966
January-June 1966	April 1967

2. Knolls Atomic Power Laboratory July-December 1966^a

*General Electric Company
Schenectady, New York*

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the AEC in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site (figure 2). The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radio-

^a Summarized from "Knolls Atomic Power Laboratory, Semiannual Environmental Monitoring Report, July-December 1966."



Figure 2. Environmental monitoring locations, KAPL

active materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory approximately 1-mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. Each environmental monitoring station is equipped with film dosimeters to detect integrated gamma radioactivity levels. The average airborne beta and gamma radioactivity at each of the three areas is summarized in table 4 for the 6-month period.

Table 4. Airborne radioactivity, KAPL, July-December 1966

Sampling period 1966	Average beta and gamma radioactivity * (pCi/m ³)		
	Knolls site	West Milton	Offsite
July.....	0.14 ± 0.01	0.18 ± 0.03	0.12 ± 0.01
August.....	.07 ± .01	.10 ± .02	.07 ± .01
September.....	.03 ± .01	.04 ± .02	.04 ± .01
October.....	.02 ± .01	.04 ± .02	.02 ± .01
November.....	.11 ± .01	.18 ± .02	.12 ± .01
December.....	.04 ± .01	.06 ± .02	.04 ± .01
July-December.....	0.07	0.10	0.07

* Samples are counted a minimum of 48 hours after collection to allow short-lived natural radionuclides to decay to nondetectable levels.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL at both the West Milton and Knolls sites. A recent perimeter survey at the site showed normal background radiation levels for the geographic location. The results of this perimeter survey, extrapolated to an annual

exposure, indicate average perimeter radiation levels of less than one-tenth roentgen per year.

Water monitoring

All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste-processing building. The release of liquid waste to the Mohawk River is regulated through the monitoring of the concentration of fission products in the collection tanks and the control of the discharge rate of the effluent.

A continuous proportional sample of the Knolls site combined-sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of the weekly composite samples show that strontium-90 is the principal radionuclide to be considered in control. The average weekly strontium-90 concentration during the period was 38 pCi/liter. The AEC radiation protection standard for this radionuclide is 300 pCi/liter. The quantity of radioactive material in the combined-sewer effluent discharged from the Knolls site has been summarized in table 5.

Table 5. Beta and gamma radioactivity in the Knolls site liquid waste effluent, July-December 1966

Sampling period 1966	Total radioactivity (mCi)	Average concentration (pCi/liter)
July.....	4.5	34
August.....	8.6	51
September.....	9.8	52
October.....	3.3	21
November.....	62.9	3.7 × 10 ³
December.....	25.5	1.8 × 10 ³
July-December.....	114.6	1.18 × 10 ³

Mohawk River water is sample continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse 8-miles upstream from the site; at the Vischer Ferry powerhouse approximately 2-miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results of this sampling along with those for precipitation are given in table 6.

The Knolls site effluent is sampled continuously for alpha radioactivity. During the second half of 1966 the semiannual discharge rate of alpha-particle emitters was less than 1 percent of the AEC environmental limit for an alpha-particle emitting radionuclide (5 × 10³

Table 6. Radioactivity in Mohawk River water and precipitation near the Knolls site, July-December 1966

Sampling period 1966	Beta and gamma radioactivity (pCi/liter)			
	G.E. Powerhouse (upstream)	Vischer Ferry (downstream)	Cohoes raw water (downstream)	Precipitation
July.....	13 ± 4	14 ± 4	8 ± 4	0.5 × 10 ³
August.....	6 ± 4	10 ± 4	7 ± 4	0.2 × 10 ³
September.....	7 ± 4	7 ± 4	9 ± 4	0.08 × 10 ³
October.....	6 ± 4	7 ± 4	7 ± 4	0.10 × 10 ³
November.....	7 ± 4	7 ± 4	9 ± 4	3.50 × 10 ³
December.....	5 ± 4	5 ± 4	4 ± 4	0.30 × 10 ³
July-December..	9 ± 4	8 ± 4	7 ± 4	0.76 × 10 ³

* Increase due to weapons testing in Asia.

pCi/liter for plutonium-239). The radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release into Glowegee Creek. Samples of the Creek water are taken once a week at two locations, one is about 150 feet above the point where the S3G effluent enters the creek and the other is about 2,640 feet below the S3G discharge or 1,500 feet below the DIG discharge. Table 7 presents a summary of radioactive wastes discharged to Glowegee Creek in terms of total radioactivity and concentration in liquid wastes.

Table 7. Beta and gamma radioactivity in West Milton liquid-waste effluents, KAPL, July-December 1966

Sampling period 1966	Total radioactivity (mCi)		Average concentration (pCi/liter)	
	D1G effluent	S3G effluent	D1G effluent	S3G effluent
July.....	0.95	0.24	100	490
August.....	.69	.26	19	120
September.....	.68	.13	16	100
October.....	.54	.19	13	110
November.....	1.23	.24	75	150
December.....	.66	.14	100	120
July-December..	4.05	1.20	26	120

3. S1C Prototype Reactor Facility July-December 1966⁵

*Combustion Engineering, Inc.
Windsor, Connecticut*

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the

⁵ Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, July 1 through December 31, 1966" (CENRD-3163-RS-562).

October 1967

Radiochemical analyses of these wastes indicated that strontium-89 and strontium-90 concentrations were less than 1 percent of the respective AEC standards during the first 3 months of this reporting period. The average results for unidentified radionuclides in the DGI and S3G effluents (26 and 120 pCi/liter) represent less than 1 percent and less than 4 percent of the applicable AEC standard of 3×10^3 pCi/liter.⁴

Table 8 presents the average concentrations of beta and gamma radioactivity detected in Glowegee Creek water upstream and downstream from the S3G and D1G liquid waste outfalls and in precipitation collected during this period.

⁴ Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0534 of the AEC Manual.

Table 8. Radioactivity in Glowegee Creek water and precipitation near the West Milton site, KAPL, July-December 1966

Sampling period 1966	Average beta and gamma radioactivity (pCi/liter)		
	Glowegee Creek (upstream)	Glowegee Creek (downstream)	Precipitation
July.....	0 ± 11	0 ± 11	1.5 × 10 ³
August.....	9 ± 10	19 ± 12	1.2 × 10 ³
September.....	4 ± 9	2 ± 9	1.4 × 10 ³
October.....	10 ± 13	1 ± 12	.3 × 10 ³
November.....	3 ± 2	1 ± 3	1.4 × 10 ³
December.....	14 ± 8	11 ± 8	0.5 × 10 ³
July-December..	7 ± 9	6 ± 9	1.1 × 10 ³

Recent coverage in *Radiological Health Data and Reports*:

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Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

The low-level radioactive waste discharged intermittently from S1C prototype operations

consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations.

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may contain small amounts of radioactive gases or particulates. This ventilation air is discharged to the environment through an exhaust stack. The ventilation air is continuously monitored for radioactivity by automated counters which control the discharge of the exhaust air. When the AEC maximum permissible concentration limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is continuously sampled for particulates at onsite and offsite locations shown in figure 3. Table 9 presents the average gross beta radioactivity

concentrations detected at air monitoring stations during the third and fourth quarters of 1966.

Table 9. Gross beta radioactivity in continuous air samples, SIC, July-December 1966

Sampling locations	Concentration (pCi/m ³)					
	July-September			October-December		
	Low	High	Average	Low	High	Average
Stack and hull exhausts	26	85	50	10	98	30
Onsite stations.....	0.12	1.6	0.9	0.23	2.5	.71
Offsite stations.....	.82	5.1	1.0	0.14	1.6	.81

Water monitoring

Liquid wastes are collected in 5,000 gallon retention tanks. If the radioactivity in a filled tank is below the allowable AEC limit for discharge to uncontrolled areas, the tank contents are released into the industrial waste system. If the limit is exceeded, the contents are diluted below the AEC radiation protection standard in a 25,000-gallon dilution tank and then released. Table 10 is a summary of the gross beta radioactivity released to the Farmington River during the second half of 1966. The concentration of specific radionuclides released to the river during this period are presented in table 11.

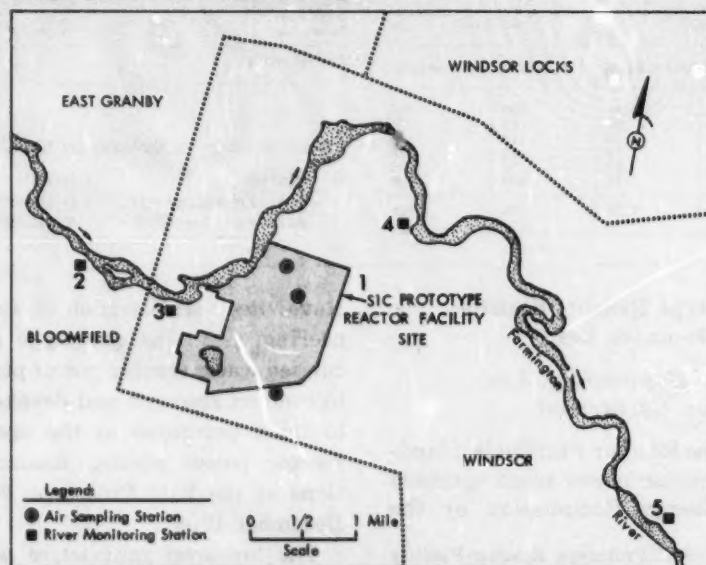


Figure 3. Environmental monitoring locations, SIC Prototype site

Table 10. Gross beta radioactivity released to the Farmington River, SIC, July-December 1966

Period	Total radioactivity (milliuries)	Average concentration (pCi/liter)
July-September	12.5	5.6×10^4
October-December	31.0	8.1×10^4

The Farmington River is sampled periodically at various locations as shown in figure 3 for determination of gross beta radioactivity in river water and mud. All 30 water samples contained less than the detectable level of 10 pCi/liter of gross beta radioactivity. All 11 mud samples contained less than the detectable level of 10 pCi/g of gross beta radioactivity.

Table 11. Concentration of specific radionuclides released to the Farmington River, SIC, July-December 1966

Radionuclide	Concentration (pCi/liter)	
	Average for second half 1966	Applicable AEC standard *
Cobalt-60	4.0×10^2	3×10^4
Iron-59	11.8×10^2	5×10^4
Manganese-54, Cobalt-58	4.1×10^2	9×10^4

* Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains the applicable AEC standards.

Recent coverage in *Radiological Health Data and Reports*:

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Reported Nuclear Detonations, September 1967

During September 1967, three U.S. underground nuclear tests were announced by the Atomic Energy Commission. The tests which were conducted underground on September 7 and September 27 at the Nevada Test Site were of low-intermediate yield (20 to 200 kilotons TNT equivalent). The underground test conducted on September 21 was of low yield (less

than 20 kilotons TNT equivalent).

The test conducted on September 21 was part of the Plowshare Program to develop peaceful uses of nuclear explosives. This was an effort to develop special emplacement techniques designed to reduce the amount of radioactivity released to the atmosphere from possible later excavation experiments.

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SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DIET MODEL FOR MEASURING RADIOACTIVITY EXPOSURE THROUGH FOOD-PILOT STUDY. *R. C. Steinkamp, N. L. Cohen, E. Hutson, and H. Kunkel. Radiological Health Data and Reports, Vol. 8, October 1967, pp. 565-573.*

This paper reports a pilot study designed to test the hypothesis that the house diet of a hospital may serve as a model for the diet of an adult population regionally served by the hospital in order to measure radioactivity exposure through food intake. Yearly and seasonal quantities of 37 subcategories of nine major food groups were compared for a Berkeley hospital house diet and diets of Berkeley and other San Francisco Bay Area residents. Results indicate that the hospital house diets while differing in certain respects from food intake of the population, may provide an estimate of near-maximum intake of foods significant for radioactive content.

KEYWORDS: California, diet, food, fruit, hospitals, milk, vegetables.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 11, November 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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State Health Department Sampling Criteria for Surveillance of Radioactivity in Milk

R. H. Neill and D. R. Snavely¹

This report summarizes criteria used by the States in setting up their milk sampling programs for measurement of radioactivity and the sample typing, collection points, and measurements used. Also included are the times required by the States from sample collection to the final radioactivity concentrations of the various radioisotopes found in milk.

Sampling criteria and related data concerning surveillance programs operated by State health agencies for radioactivity in milk are summarized in this report. The information is primarily based on survey results secured during the last quarter of 1965 from State radiological health program personnel.

Earlier reports have been published concerning agencies known to have been actively conducting milk surveillance in 1960 (1) and on general details of State surveillance programs for radioactivity in milk as they had developed by 1963 (2). The 1965 survey was directed toward determining to what extent there are common denominators or differences in sampling criteria employed among the State programs. The survey was considered a necessary first step in inventorying the potential for mutual support among State and Federal environmental radiation control programs.

¹ Mr. Neill is associate chief, Standards and Intelligence Branch, and Mr. Snavely is staff officer, Radiological Health Standards Section, Standards and Intelligence Branch, NCRH, Rockville, Md. 20852.

Survey procedure

State health department officials involved with radiological health programs were requested to supply detailed information under the following survey form categories: (1) basis for selecting milk sampling locations, (2) sampling procedures for raw and/or pasteurized milk, (3) average time from the date of sample collection, under both routine and emergency conditions, for analytical results to be made available, and (4) proposed plans for modifying routine and emergency milk surveillance networks in the near future. Of the 39 States operating some type of milk surveillance program, responses were received from 38. Therefore, the following tables are based on these 38 States. The results were summarized by common criteria under each of the four categories.

Operational status of State milk surveillance programs

The increased State participation in milk surveillance programs is illustrated in figure 1. By October 1965, 39 States had some type of surveillance program for radioactivity in milk.

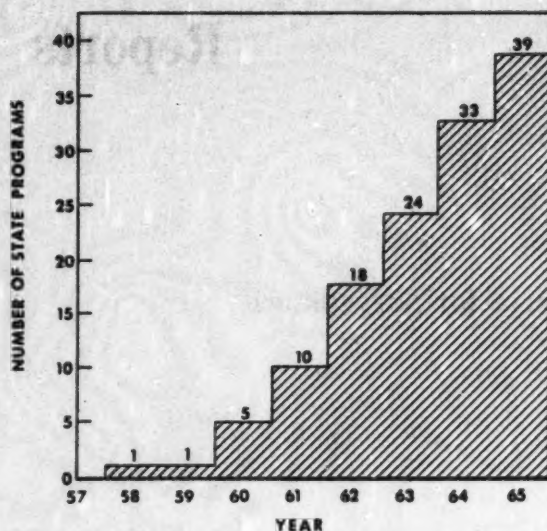


Figure 1. Number of State milk surveillance programs by year

The operational status of these programs may be classified into the following three groups and are shown in figure 2:

1. **ACTIVE:** Both sampling and analysis capabilities exist and are operating.
2. **LIMITED ACTIVE:** Sampling is performed by the State, but analysis is performed by a non-State agency.
3. **INACTIVE:** Networks are presently inoperative, but both sampling and analysis have been previously conducted and can be reactivated.

Basis for selecting State milk sampling locations

Four bases for selecting milk sampling locations were identified and listed on the survey form. These were geography, population, milk production and/or processing, and nuclear facilities. A fifth category of "other" was also included. Thirty-one States used one or two of these bases. A summary of sampling location bases for these 31 States appears below in table 1 and includes States with all three degrees of operational status. Those States sampling raw or pasteurized milk or both are also listed in table 1. The individual numbers appearing in each box indicate the number of

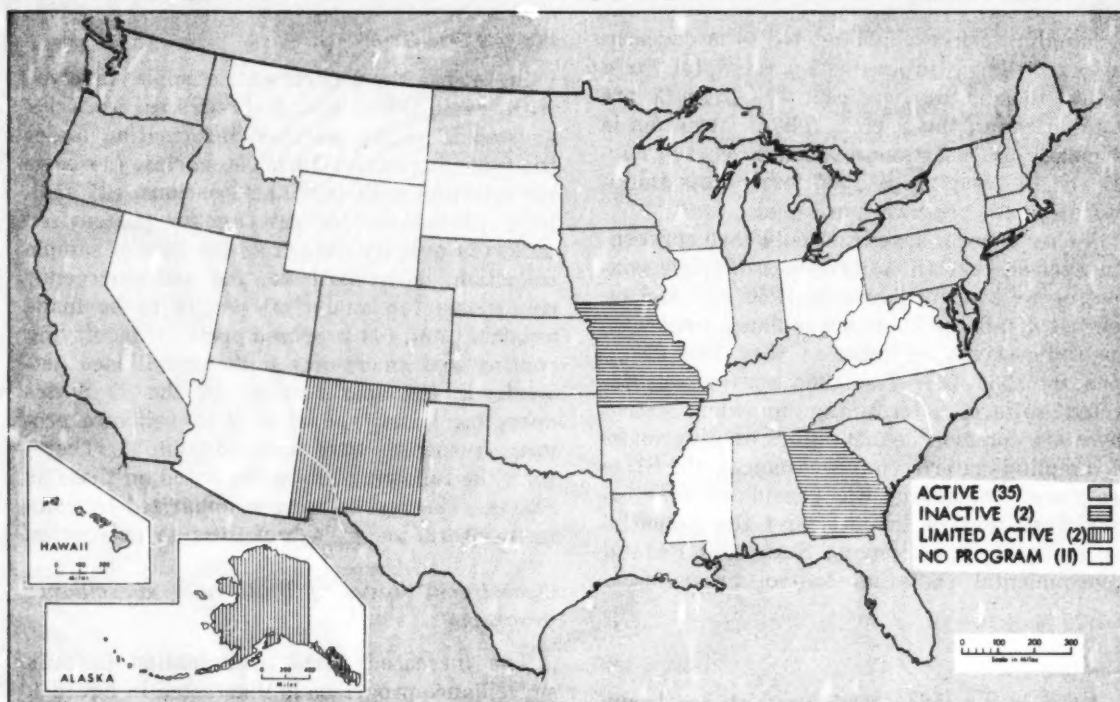


Figure 2. Operational status of State milk surveillance program October 1965

States that selected the applicable sampling location bases under raw or pasteurized milk or both. An explanation of table 1 follows:

	Type of milk	Population (b)
Geography (a)	Raw only	1
	Pasteurized only	1
	Both	0

The criteria "Geography" and "Population" were used to establish sampling networks by one State that sampled only raw milk, one State that only sampled pasteurized milk and there were not any States that sampled both types of milk. Therefore, two States used both (a) and (b) criteria.

As observed in table 1, four of the six States sampling only raw milk indicated considerations of "geography," singly and in combinations, as the predominant basis for selecting their sampling locations. Among the 15 States with only pasteurized milk sampling programs, the basis of "production and processing" figured in the sampling plans of 10 of them, with "geography" ranking as the next most common basis in seven State programs. The basis of "population" figured in only two of the six raw milk sampling programs and in only three of the fifteen pasteurized milk sampling programs.

Three States were found to use a combination of three sampling location bases—geography, population, and production and processing. Two States indicated four bases were considered in selecting sampling locations and one State reported using all four plus the category of "other." Table 2 summarizes the sampling location bases used by the seven States where three or more bases were involved.

Table 2. Type of milk sampled by States using more than two bases to determine sampling location

Sampling code *	Raw milk only	Pasteurized milk only	Both
(a), (b), (c)	1	1	1
(a), (b), (c), (d)	0	1	1
(a), (b), (c), (e)	1	0	0
(a), (b), (c), (d), (e)	0	1	0

* See table 1 for sampling basis identification.

Sampling procedures for raw and pasteurized milk sample collection points

Once a decision has been made regarding a basis (or bases) for locating stations in a milk sampling network, a closely related consideration involves selecting a specific link in the milk production, processing and distribution chain at which samples will be collected. These links or points at which milk samples are collected

Table 1. Number of States using one or two bases for selecting milk sampling locations

Basis for selecting milk sampling location	Code	Type of milk	Geography (a)	Population (b)	Production and processing (c)	Nuclear facilities (d)	Other (e)	Total
Geography	(a)	Raw only	2	1	0	0	1	4
		Pasteurized only	2	1	3	0	1	7
		Both	3	0	1	2	0	6
Population	(b)	Raw only		1	0	0	0	1
		Pasteurized only		0	2	0	0	2
		Both		0	0	0	0	0
Production and processing	(c)	Raw only			0	0	0	0
		Pasteurized only			5	0	0	5
		Both			2	1	1	4
Nuclear facilities	(d)	Raw only				1	0	1
		Pasteurized only				0	1	1
		Both				0	0	0
Other	(e)	Raw only					0	0
		Pasteurized only					0	0
		Both					0	0
Total		Raw only						6
		Pasteurized only						15
		Both						10

will vary depending on the type of milk sampled. Information on the location of the collection sites of the State milk programs was also obtained and is summarized on figure 3.

Table 3 summarizes sample collection points for the 16 State raw and raw plus pasteurized milk sampling locations. "Farm" and "farm and storage tank" responses for sampling points were combined; "storage tank" responses were maintained separately as these can be associated with raw milk as well as with pasteurized milk sampling programs. It can be observed that twice as many "farm" sample collection points as "tank truck" sample collection points were reported. Table 4 displays similar information for those raw milk and

raw plus pasteurized milk sampling programs which utilized three or more bases for determining sampling locations.

Table 5 lists those sample collection points for pasteurized milk and for pasteurized plus raw milk sampling programs stratified by one or two bases for determining sampling locations. The majority of sample collection points falls under the headings of "plant" and "plant and retail outlet." The overlap in numbers of State programs between table 5 and table 3 should be noted. This is explained by the ten States which reported sampling both raw and pasteurized milk. Similarly, table 6 illustrates the pattern of sample collection points utilized by pasteurized milk, and pasteurized and raw

Table 3. Sample collection points for raw and raw plus pasteurized milk sampling programs *

Basis for selecting milk sampling location	Code	Sample collected from:	Number of States selecting criteria					
			Geography (a)	Population (b)	Production and processing (c)	Nuclear facilities (d)	Other (e)	Total
Geography	(a)	Farm and/or farm storage tank	3	0	0	2	1	6
		Tank truck	1	1	1	0	0	3
		Storage tank	1	0	0	0	0	1
Population	(b)	Farm and/or farm storage tank		0	0	0	0	0
		Tank truck		1	0	0	0	1
		Storage tank		0	0	0	0	0
Production and processing	(c)	Farm and/or farm storage tank			1	1	0	2
		Tank truck			0	0	0	0
		Storage tank			1	0	1	2
Nuclear facilities	(d)	Farm and/or farm storage tank				1	0	1
		Tank truck				0	0	0
		Storage tank				0	0	0
Other	(e)	Farm and/or farm storage tank					0	0
		Tank truck					0	0
		Storage tank					0	0
Total		Farm and/or farm storage tank						9
		Tank truck						4
		Storage tank						3

* Limited to State programs stratified by 1 or 2 bases for determining sampling locations.

^b See text.

Table 4. Sample collection points for raw and raw plus pasteurized milk sampling programs *

Sampling code ^b	Farm and/or farm storage tank	Tank truck	Storage tank
(a), (b), (c)	0	1	1
(a), (b), (c), (d)	1	0	0
(a), (b), (c), (e)	1	0	0
(a), (b), (c), (d), (e)	0	0	0

* Limited to State programs stratified by three or more bases for determining sampling locations.

^b See table 3 for sampling bases identification.

milk sampling programs where three or more bases for establishing sampling locations were used.

Sampling frequencies and compositing practices

Of the 38 States responding to the questionnaire at the time the survey was carried out, five States sampled on at least a daily basis, 14 States had weekly programs, another 14 States sampled on at least a monthly basis and 5 States had quarterly surveillance programs.

65

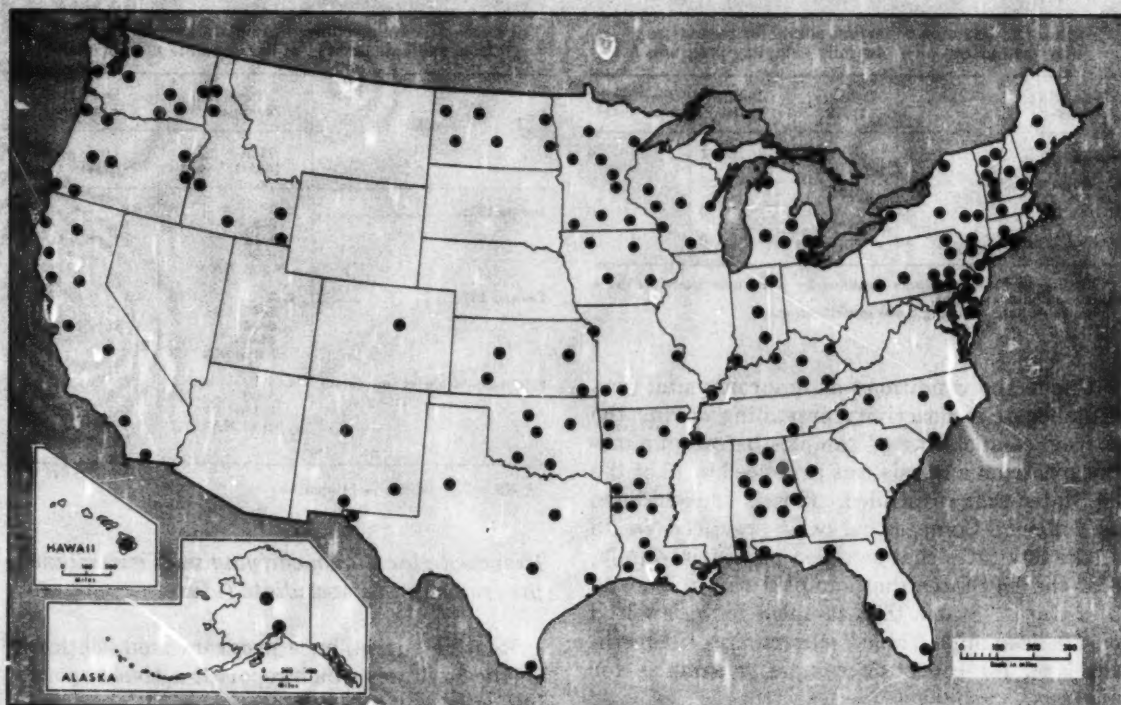


Figure 3. Sample collection sites of State milk programs October 1965

Table 5. Sample collection points for pasteurized and pasteurized plus raw milk sampling programs *

Basis for selecting milk sampling location	Code	Sample collected from:	Number of States selecting criteria					Total
			Geography (a)	Population (b)	Production and processing (c)	Nuclear facilities (d)	Other (e)	
Geography.....	(a)	Plant.....	2	1	2	0	0	5
		Delivery truck.....	0	0	1	0	0	1
		Retail outlet.....	1	0	0	1	0	2
		Plant & retail outlet.....	2	0	1	1	1	5
Population.....	(b)	Plant.....		0	1	0	0	1
		Delivery truck.....		0	0	0	0	0
		Retail outlet.....		0	1	0	0	1
		Plant & retail outlet.....		0	0	0	0	0
Production and processing.....	(c)	Plant.....			5	0	1	6
		Delivery truck.....			1	0	0	1
		Retail outlet.....			1	0	0	1
		Plant & retail outlet.....			0	1	0	1
Nuclear facilities.....	(d)	Plant.....				0	0	0
		Delivery truck.....				0	1	1
		Retail outlet.....				0	0	0
		Plant & retail outlet.....				0	0	0
Other.....	(e)	Plant.....					0	0
		Delivery truck.....					0	0
		Retail outlet.....					0	0
		Plant & retail outlet.....					0	0
Total.....		Plant.....						12
		Delivery truck.....						3
		Retail outlet.....						4
		Plant & retail outlet.....						6

* Limited to State programs stratified by 1 or 2 bases for determining sampling locations.

Table 6. Sample collection points for pasteurized and pasteurized plus raw milk sampling programs *

Sampling basis ^b	Plant	Delivery truck	Retail outlet	Plant and retail outlet
(a), (b), (c) -----	1	0	1	0
(a), (b), (c), (d) ..	1	0	0	1
(a), (b), (c), (e) ..	0	0	0	0
(a), (b), (c), (d), (e)	0	0	0	1

* Limited to State programs stratified by 3 or more bases for determining sampling locations.

^b See table 5 for sampling bases identification.

Under the conditions of environmental surveillance of radioactivity prevailing during the survey, compositing of samples before gamma-ray spectrum analysis was practiced in 18 of the 38 States that responded. This is broken down as follows: Compositing was practiced in 13 of the 30 States that sampled pasteurized milk, 8 of the 20 States that sampled raw milk, and 3 of the 12 States that sampled both raw and pasteurized milk. Table 7 summarizes the methods used for collecting composite samples for analysis.

Table 7. Method of compositing milk samples

Method	No. of States sampling pasteurized milk	No. of States sampling raw milk
By equal subsample volumes	7	5
By subsample volumes proportional to milk production or consumption represented by subsample	4	2
By subsample volumes proportional to time interval represented by subsample	2	1

Average time periods for obtaining analytical results

The average time between collection of milk samples and obtaining analytical results is one measure of the efficiency of a sampling program, particularly with respect to reducing the dose from iodine-131 to the milk drinking population through protective action. Table 8 summarizes the periods of time required to obtain analytical results for four radionuclides under routine and emergency conditions.

Table 8. Time required to obtain analytical results from radionuclides in milk from date of collection

Nuclide	Routine conditions		Emergency conditions	
	Time (days)	No. of States	Time (days)	No. of States
Iodine-131	< 3 3-7 8-14 15-30 NS or NA *	18 10 3 3 4	<1 1-3 NS or NA	12 10 7
Cesium-137	< 3 3-7 8-14 15-30 NS or NA	16 9 2 3 8	<1 1-3 NS or NA	10 17 11
Strontium-90 and strontium-90 ..	<15 15-30 31-120 NS or NA	9 17 5 7	<1 1-3 4-7 8-30 NS or NA	1 11 5 11 10

* NS or NA, no sample or analysis.

Proposed plans for modifying milk surveillance programs in the immediate future

Routine surveillance program modifications: Of the 34 States which reported actively operating milk surveillance programs, 17 indicated no immediate changes were contemplated in their present method of surveillance. One State intended to decrease its sampling program, and five States planned to expand their programs, either by increasing the number of sampling locations or by improving their radioanalytical capabilities.

Emergency surveillance program modifications: Seven States indicated that no changes were planned. Two States were developing plans for using ion exchange cartridges for iodine-131 determinations. One State indicated intentions of establishing a new laboratory nearer to an important potential source for the release of fission products and another State had plans to expand its basic data on milk sampling locations.

Discussion and summary

No attempt was made in the survey forms to define a single basis for reporting how milk sampling locations were selected. Instead, latitude was given the survey respondents to report more than one basis if that were the case.

The results showed that "geography" was the basis most frequently reported for selecting raw milk sampling locations. This is not unexpected since raw milk is sampled at a farm or farms—a geographical criterion. "Geography" combined with "milk production and processing" were observed as the predominant bases for selecting pasteurized milk sampling locations. "Population" appeared to be the least employed basis among all types of sampling programs.

For pasteurized milk, one must recognize that the terms "geography," "population," and "milk processing" (pasteurization and bottling) may not all be mutually exclusive. For example, processing centers may be located adjacent to major population centers. Respondents could check one or both of these criteria. Additionally, milk sampling locations could be selected for cities of a certain size in different counties. Here respondents could have checked "geography," "population," or both.

"Farms and/or farm storage tanks" were preferred over "tank trucks" for raw milk collection points. Among the pasteurized milk sampling programs, a preference was observed for "milk processing plants" over "retail outlets." As of the last quarter of 1965, 30 of the 38 reporting States were sampling on a weekly basis.

The majority of States using gamma-ray spectrometry can report results for iodine-131 and cesium-137 within 3 days of sample collection.

While State surveillance programs for radioactivity in milk at the time the survey was conducted embraced more than three-fourths of the States, the survey results disclose no common denominators among the States with respect to selecting sampling locations or other sampling details. Where States or cities are supplied with interstate milk shipments, the need for uniformity in sampling procedures among the States is particularly important for effective radiation control programs, particularly those involving protective action procedures.

Acknowledgements

The authors wish to acknowledge with appreciation the efforts of State health department personnel who responded to the survey which produced the results summarized in this report, and to the nine Regional representatives of the National Center for Radiological Health, who were responsible for contacting the States and securing the completed forms.

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SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Both Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other. They do provide an indication of when there is a need to initiate careful evaluation of exposure (3). Additional guidelines are provided

by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in

milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program
Radiostrontium in milk, HASL

Period reported
July-December 1966

Last presented
September 1967

1. Pasteurized Milk Network July 1967

*National Center for Radiological Health and
National Center for Urban and Industrial
Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) pro-

vides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical pro-

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Radionuclide	Concentration (pCi/liter)	Error * (pCi/liter)	Concentration (pCi/liter)	Error * (percent of concentration)
Strontium-90	< 50	5	≥ 50	10
Strontium-90	< 20	2	≥ 20	10
Iodine-131	< 100	10	≥ 100	10
Cesium-137	< 100	10	≥ 100	10
Barium-140	< 100	10	≥ 100	10

* Two standard deviations.

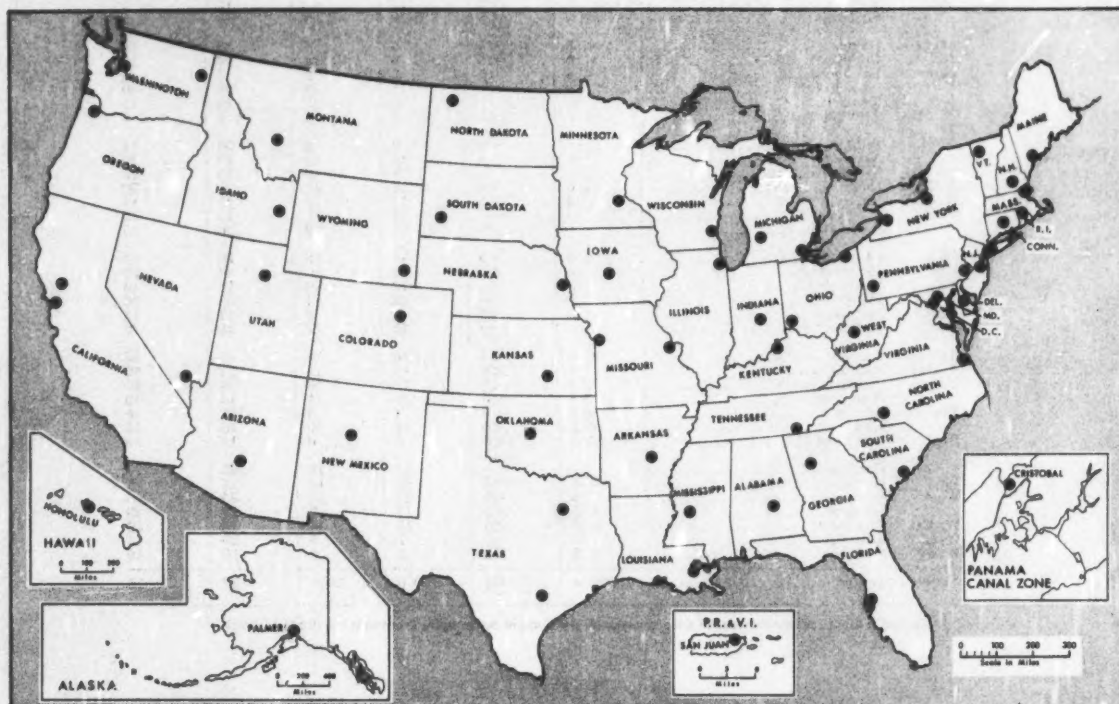


Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in pasteurized milk for the second quarter 1967 and July 1967

Sampling location		Radionuclide concentration ($\mu\text{Ci/liter}$)					
		Strontium-90		Strontium-90		Cesium-137	
		Second quarter 1967	July 1967	Second quarter 1967	July 1967	Second quarter 1967	July 1967
Ala:	Montgomery.....	< 5	< 5	10	10	15	15
Alaska:	Palmer.....	< 5	< 5	7	6	20	20
Aris:	Phoenix.....	< 5	< 5	4	2	< 5	5
Ark:	Little Rock.....	< 5	< 5	27	23	20	20
Calif:	Sacramento.....	10	< 5	5	4	10	10
	San Francisco.....	10	< 5	5	3	10	5
C.2:	Cristobal.....	< 5	< 5	5	5	30	20
Colo:	Denver.....	< 5	< 5	6	8	10	15
Conn:	Hartford.....	—	—	9	11	20	20
Del:	Wilmington.....	—	—	12	12	15	15
D.C:	Washington.....	< 5	< 5	10	11	15	10
Fla:	Tampa.....	< 5	< 5	9	8	75	70
Ge:	Atlanta.....	< 5	< 5	17	16	25	25
Hawaii:	Honolulu.....	< 5	< 5	4	5	10	10
Idaho:	Idaho Falls.....	< 5	< 5	7	7	10	15
Ill:	Chicago.....	< 5	< 5	10	7	15	10
Ind:	Indianapolis.....	—	—	10	10	15	10
Iowa:	Des Moines.....	< 5	< 5	9	9	15	10
Kans:	Wichita.....	< 5	< 5	8	9	10	10
Ky:	Louisville.....	< 5	< 5	15	14	10	15
La:	New Orleans.....	< 5	< 5	28	21	30	30
Maine:	Portland.....	—	—	12	13	35	35
Md:	Baltimore.....	< 5	< 5	13	11	20	10
Mass:	Boston.....	< 5	< 5	12	14	35	35
Mich:	Detroit.....	—	—	9	9	15	15
	Grand Rapids.....	—	—	11	12	25	15
Minn:	Minneapolis.....	< 5	< 5	14	15	20	15
Miss:	Jackson.....	< 5	< 5	21	21	20	15
Mo:	Kansas.....	5	< 5	10	11	10	< 5
	St. Louis.....	5	< 5	10	9	10	< 5
Mont:	Helena.....	< 5	< 5	6	6	10	10
Nebr:	Omaha.....	< 5	< 5	5	14	10	10
Nev:	Las Vegas.....	< 5	< 5	2	3	5	5
N.H:	Manchester.....	—	—	15	19	30	30
N.J:	Trenton.....	—	—	10	10	20	15
N. Mex:	Albuquerque.....	< 5	< 5	3	3	< 5	< 5
N.Y:	Buffalo.....	—	—	9	8	20	15
	New York.....	—	—	12	15	20	20
N.C:	Syracuse.....	—	—	9	10	20	15
N. Dak:	Charlotte.....	< 5	< 5	19	17	20	20
Ohio:	Minot.....	5	< 5	17	12	25	15
	Cincinnati.....	—	—	11	11	15	10
	Cleveland.....	—	—	11	10	20	15
Okla:	Oklahoma City.....	< 5	< 5	12	10	10	10
Ore:	Portland.....	5	< 5	10	10	20	20
Pa:	Philadelphia.....	—	—	10	9	15	10
P.R:	Pittsburgh.....	—	—	15	14	25	20
	San Juan.....	< 5	< 5	4	7	15	15
R.I:	Providence.....	—	—	11	14	25	30
S.C:	Charleston.....	< 5	< 5	16	17	35	30
S. Dak:	Rapid City.....	5	< 5	14	12	15	20
Tenn:	Chattanooga.....	< 5	< 5	17	18	20	20
	Memphis.....	< 5	< 5	16	14	10	10
Tex:	Austin.....	< 5	< 5	4	3	10	5
	Dallas.....	< 5	< 5	12	10	15	15
Utah:	Salt Lake City.....	< 5	< 5	6	6	15	20
Vt:	Burlington.....	—	—	11	13	25	20
Va:	Norfolk.....	< 5	< 5	14	14	15	15
Wash:	Seattle.....	< 5	< 5	12	11	35	45
	Spokane.....	< 5	< 5	12	9	20	20
W. Va:	Charleston.....	< 5	< 5	15	13	15	10
Wisc:	Milwaukee.....	< 5	< 5	7	9	20	15
Wyo:	Laramie.....	< 5	< 5	5	5	10	10
Network average.....		< 5	< 5	10.9	10.7	20	15

* Dashes indicate no strontium-90 determinations were made on samples from station during month.

cedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The minimum detectable concentration is defined as the measured concentration equal to 2 standard deviations of the analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, 10; barium-140, 10; and iodine-131, 10. At these levels and below, the counting error

comprises nearly all of the analytical error. The results for the second quarter of 1967 and July 1967, are presented in table 2. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values are below minimum detectable concentrations, averages are calculated using one-half of the minimum detectable values; however, for iodine-131 and barium-140, zero is used for averaging purposes when concentrations are below minimum detectable levels. Because all values for iodine-131 and barium-140 are below minimum detectable concentrations during the period covered in this report, results for these two radionuclides are not included in table 2.

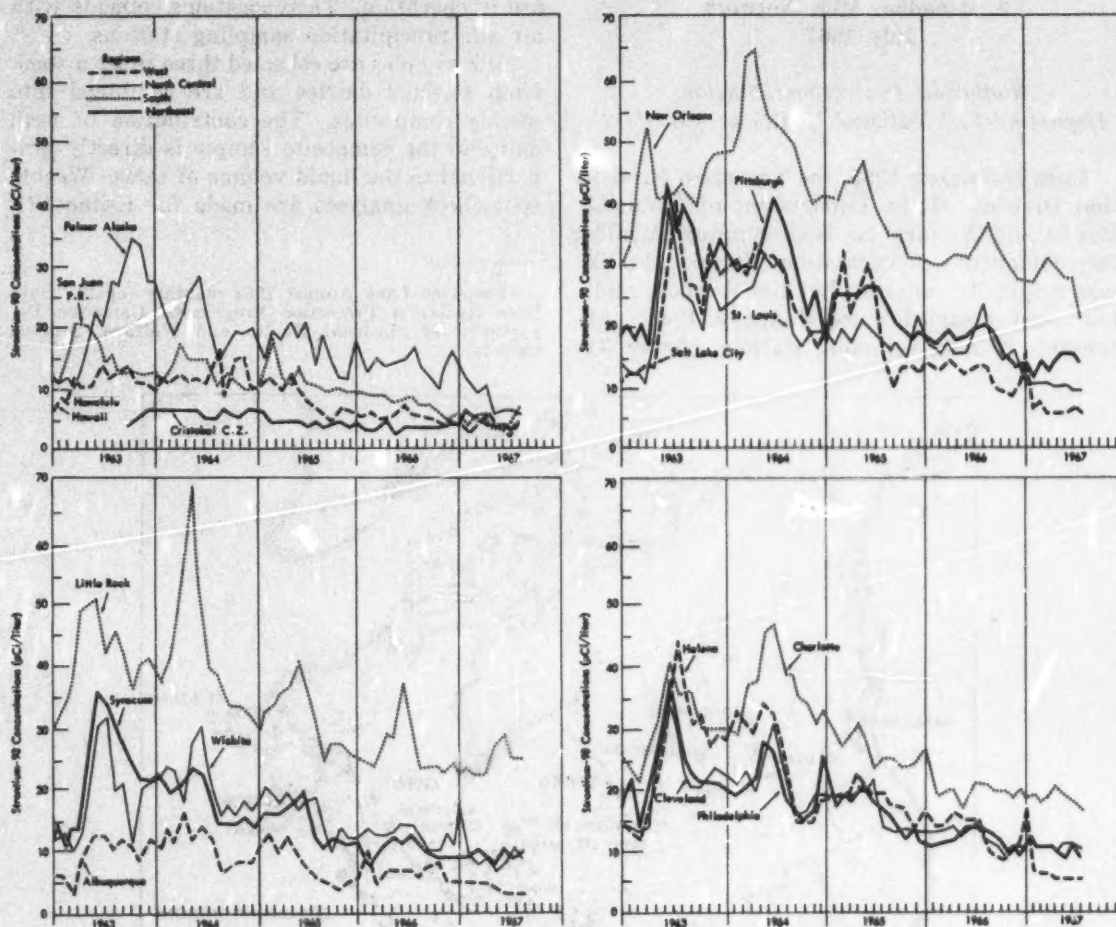


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-July 1967

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 3 and 4 for July 1966 and February

through July 1967. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium-90 concentrations in milk at PMN stations, July 1966, February-July 1967

Strontium-90 (pCi/liter)	Number of stations *						
	1966		1967				
	July	Feb	Mar	Apr	May	June	July
Under 10...	14 (23%)	21 (33)	25 (40)	25 (40)	25 (40)	27 (43)	25 (40)
10-19.....	39 (62)	38 (61)	35 (55)	34 (54)	35 (55)	34 (54)	35 (55)
20-29.....	9 (14)	4 (6)	2 (3)	4 (6)	3 (5)	2 (3)	3 (5)
30-39.....	1 (2)	0 (0)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)

* Percentage of stations shown in parentheses.

Table 4. Frequency distribution, cesium-137 concentrations in milk at PMN stations, July 1966, February-July 1967

Cesium-137 (pCi/liter)	Number of stations *						
	1966		1967				
	July	Feb	Mar	Apr	May	June	July
Under 50...	56 (89%)	63 (98)	62 (98)	62 (98)	61 (97)	61 (97)	61 (97)
50-99.....	6 (9)	1 (2)	1 (2)	1 (2)	2 (3)	2 (3)	2 (3)
100-149....	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

* Percentage of stations shown in parentheses.

2. Canadian Milk Network July 1967 ¹

*Radiation Protection Division
Department of National Health and Welfare*

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3)

are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131,

¹ Prepared from August 1967 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.



Figure 3. Canadian milk sampling stations

and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The July 1967 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, July 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary.....	1.12	1.5	12	19
Edmonton.....	1.10	1.6	10	25
Ft. William.....	1.09	NS	18	NS
Fredericton.....	1.03	1.4	21	17
Halifax.....	1.10	1.6	21	32
Montreal.....	1.06	1.5	10	19
Ottawa.....	1.13	NS	11	NS
Quebec.....	1.06	1.5	18	23
Regina.....	1.06	1.6	10	14
St. John's, Nfld.....	1.16	1.6	34	85
Saskatoon.....	1.09	1.6	10	13
Sault Ste. Marie.....	1.10	1.7	19	34
Toronto.....	1.11	1.6	8	7
Vancouver.....	1.19	1.5	16	63
Windsor.....	1.13	1.5	8	10
Winnipeg.....	1.06	1.6	9	23
Average.....	1.10	1.6	15	38

NS, no sample.

3. Pan American Milk Sampling Program July 1967

*Pan American Health Organization and
U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).

November 1967



Figure 4. Pan American Milk Sampling Program locations

Table 6 presents stable potassium, strontium-90, and cesium-137 monthly average concentrations for July 1967.

Table 6. Stable element and radionuclide concentrations in PAHO milk, July 1967 *

Sampling station	Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile: Santiago.....	4	1.6	4	15
Colombia: Bogota.....	1	1.4	3	< 5
Ecuador: Guayaquil.....	1	1.5	<1	10
Jamaica: Kingston.....	1	1.5	6	105
Venezuela: Caracas.....	1	1.5	4	10
Canal Zone: Cristobal ^b	5	-----	5	20
Puerto Rico: San Juan ^b	5	-----	7	15

* Iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples. Strontium-89 was less than 5 pCi/liter for all samples.

^b For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone and San Juan, Puerto Rico, from the Pasteurized Milk Network, are presented.

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State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing develop-

mental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in the current issue are highlighted in the figure. A summary of State programs previously covered, the reporting period, and issue of appearance are as follows:

State milk network	Period reported	Last presented
California	January-March 1967	September 1967
Colorado	April-June 1967	October 1967
Florida	April-June 1967	October 1967
Oklahoma	April-June 1967	October 1967
Oregon	January-March 1967	September 1967
Tennessee	April-June 1967	October 1967
Texas	April-June 1967	October 1967
Washington	January-March 1967	September 1967

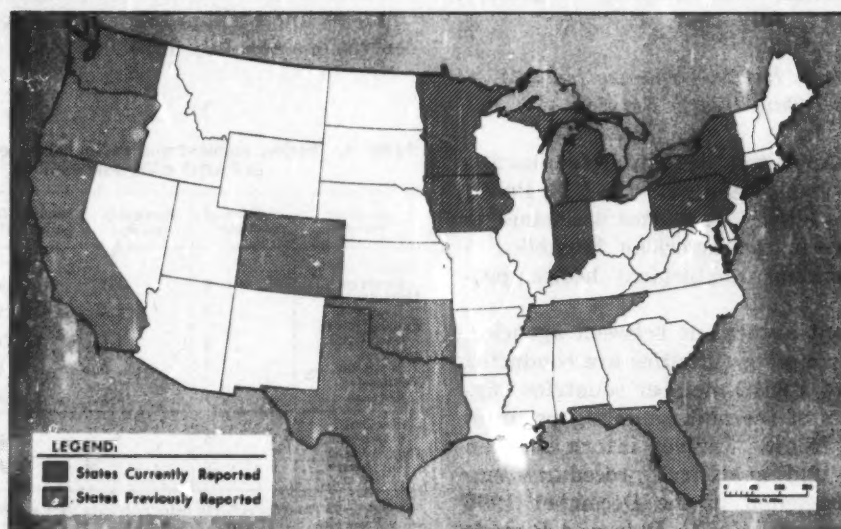


Figure 1. State milk programs reported

1. Connecticut Milk Network April-June 1967

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium-89 and strontium-90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 2). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium-89, strontium-90, and gamma-ray emitters. Concentrations of iodine-131 are determined as an indication of the presence of radioactivity of recent origin.

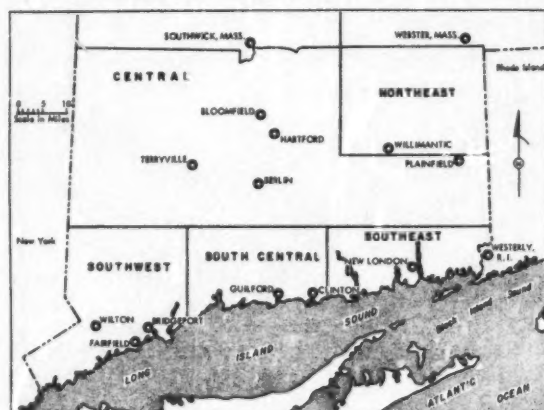


Figure 2. Connecticut pasteurized milk sampling areas

Strontium-89 and strontium-90 are determined by chemical separation. Iodine-131 and other gamma-ray emitters are determined by gamma-ray scintillation spectroscopy.

The monthly average concentrations of strontium-89, strontium-90, iodine-131, and cesium-137 in central Connecticut pasteurized

milk are presented in table 1. These results are presented graphically in figure 3.

Table 1. Radionuclide concentrations in central Connecticut pasteurized milk, April-June 1967

Month	Radionuclide concentrations (pCi/liter)			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
April-----	ND	10	<10	20
May-----	ND	9	<10	20
June-----	ND	11	<10	20

ND, below detectable levels.

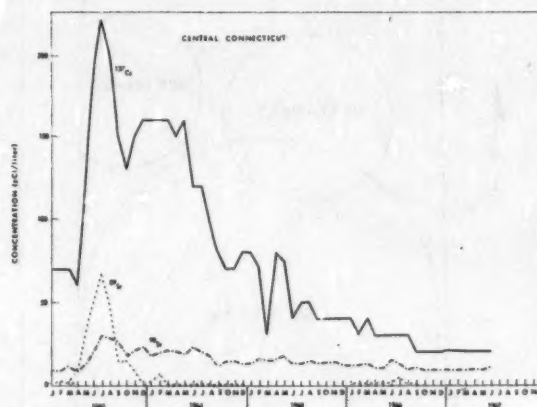


Figure 3. Radionuclide concentration in central Connecticut pasteurized milk, 1963-June 1967

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	May 1967
January-March 1967	August 1967

Recent coverage in *Radiological Health Data and Reports* for Indiana Milk Network:

Period	Issue
October-December 1966	May 1967
January-March 1967	August 1967

2. Indiana Milk Network April-June 1967

Bureau of Environmental Sanitation Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 4). One large dairy within each milkshed was assumed to be representative for sampling purposes.

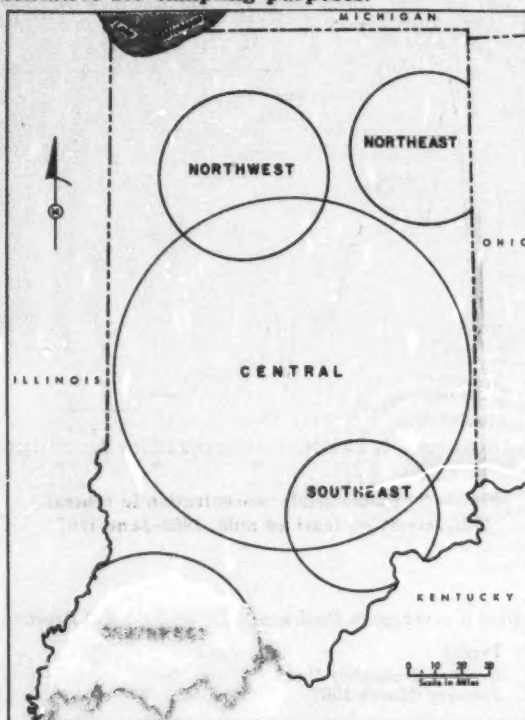


Figure 4. Indiana pasteurized milk sampling areas

The milk samples are analyzed monthly for strontium-89 and strontium-90. Cesium-137, iodine-131, and barium-140 are analyzed weekly for at least two of the milksheds. When iodine-131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for the northeast, southeast, and southwest milksheds.

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (1,2) while cesium-137, iodine-131, and barium-140 are determined by gamma-ray scintillation spectrometry (3).

The monthly stable element and radionuclide concentrations in Indiana pasteurized milk are presented by sampling locations in table 2 for April through June 1967.

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 5. Barium-140 concentrations remained below detectable levels of 10 pCi/liter during this period.

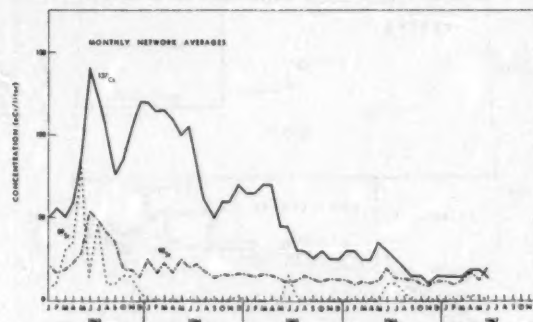


Figure 5. Radionuclide concentrations in Indiana pasteurized milk, 1963-June 1967

Table 2. Radionuclides in Indiana pasteurized milk, April-June 1967

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-89 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	April	May	June	April	May	June	April	May	June	April	May	June	April	May	June
Northeast.....	1.10	1.22	1.15	1,360	1,370	1,330	5	0	0	14	14	30	20	20	15
Southeast.....	1.10	1.26	1.20	1,380	1,290	1,330	0	10	0	19	15	20	20	20	15
Central.....	1.14	1.22	1.15	1,330	1,310	1,310	10	5	0	21	11	20	10	15	10
Southwest.....	1.14	1.22	1.20	1,300	1,370	1,330	20	5	0	25	16	18	20	20	10
Northwest.....	1.16	1.20	1.10	1,300	1,350	1,330	0	0	0	16	14	19	20	20	15
Average.....	1.13	1.22	1.16	1,330	1,340	1,330	5	5	0	19	14	21	20	20	15

3. Iowa Milk Network April-June 1967

*State Hygienic Laboratory and the Iowa State
Department of Health*

In Iowa, radiological health activities are conducted jointly by the State Department of Health and the State Hygienic Laboratory, with the State Hygienic Laboratory performing the surveillance and analytical functions. In August 1962, the State Hygienic Laboratory of Iowa began sampling milk for iodine-131. In May 1964 this routine surveillance was expanded to include cesium-137 and strontium-90.

One gallon samples are collected from four stations, selected to give a broad coverage of milk production areas in the State (figure 6). Producers furnishing milk to the Spencer bottling area are restricted to that north-



Figure 6. Iowa milk sampling locations

west part of the State and the majority of milk bottled in Iowa City comes from six counties in east central Iowa. The Des Moines milkshed comprises approximately 60 counties covering about two-thirds of the State radiating out of Des Moines in all directions. The Charles City bottling area covers primarily north central Iowa. At present the Iowa City and Des Moines stations are sampled weekly and the Spencer and Charles City stations are sampled monthly.

This sampling frequency is increased when nuclide concentrations warrant closer surveillance. The samples are forwarded to the State Hygienic Laboratory at the University of Iowa, Iowa City, for analysis.

Analytical procedures

Iodine-131 and cesium-137 together with barium-lanthanum-140 and potassium-40 are determined by gamma-ray scintillation spectrometry using a 4- by 4-inch NaI (TI) crystal and 512 channel pulse-height analyzer. All samples are 3.5 liters and are counted for 80 minutes in Marinelli beakers with the results being calculated using a 4 by 4 matrix. Strontium-90 is determined by an ion-exchange system described by Porter *et al.* (1). One liter of milk is passed through an ion exchange column; yttrium-90 is eluted from the resin and counted as yttrium oxalate in an automatic low-background proportional counter. Minimum detectable limits are 10 pCi/liter for iodine-131 and cesium-137, and 2 pCi/liter for strontium-90.

Results

Table 3 gives the monthly average at each of the four locations for April-June 1967 and figure 7 shows graphically the overall network average monthly results for the same period.

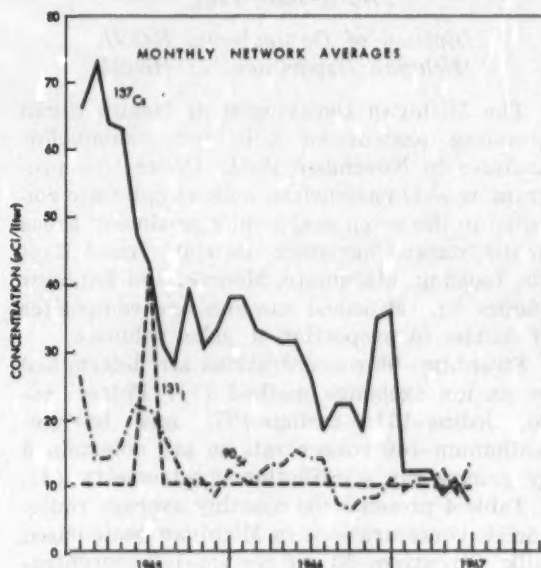


Figure 7. Radionuclide concentrations in Iowa milk
January 1965-June 1967

Table 3. Radionuclide concentrations in Iowa milk, April-June 1967

Sampling location	Radionuclide concentrations (pCi/liter)								
	Strontium-90			Cesium-137			Iodine-131		
	April	May	June	April	May	June	April	May	June
Iowa City.....	12	9	10	11	8	9	<10	<10	<10
Des Moines.....	10	8	12	7	7	9	<10	<10	<10
Spencer.....	13	NA	NA	12	NA	NA	<10	NA	NA
Charles City.....	13	9	17	<10	19	<10	<10	<10	<10
Average.....	12	9	13	9	11	8	<10	<10	<10

NA, no analysis to date.

During this period it can be seen that the concentration levels of cesium-137 and strontium-90 showed a decreasing trend.

Recent coverage in *Radiological Health Data and Reports*:

<u>Period</u>	<u>Issue</u>
January-1965-March 1967	August 1967

4. Michigan Milk Network April-June 1967

*Division of Occupational Health
Michigan Department of Health*

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 8). Milkshed samples are composites of dairies in proportion to sales volumes.

Strontium-90 concentrations are determined by an ion exchange method (5). Potassium-40, iodine-131, cesium-137, and barium-lanthanum-140 concentrations are determined by gamma-ray scintillation spectrometry (5).

Table 4 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium-90 and cesium-137 concentrations are presented graphically in figure 9 to show general trends.



Figure 8. Michigan pasteurized milk network sampling locations

Radiological Health Data and Reports

Table 4. Radionuclide concentrations in Michigan pasteurized milk, April-June 1967

Sampling location	Month	Radionuclide concentration (pCi/liter)			
		Potassium-40	Strontium-90	Iodine-131	Cesium-137
Charlevoix	April	1,360	6	<14	20
	May	1,360	8	<14	23
	June	1,360	6	<14	20
Detroit	April	1,370	4	<14	14
	May	1,370	4	<14	15
	June	1,330	4	<14	10
Grand Rapids	April	1,360	5	<14	16
	May	1,360	7	<14	17
	June	1,330	6	<14	13
Lansing	April	1,360	4	<14	13
	May	1,330	6	<14	14
	June	1,370	4	<14	9
Marquette	April	1,380	10	<14	28
	May	1,390	7	<14	30
	June	1,330	10	<14	26
Monroe	April	1,360	3	<14	10
	May	1,360	10	<14	10
	June	1,330	4	<14	9
Saginaw	April	1,340	3	<14	11
	May	1,330	5	<14	15
	June	1,290	4	<14	10
Average	April	1,360	5	<14	16
	May	1,350	7	<14	18
	June	1,340	5	<14	14

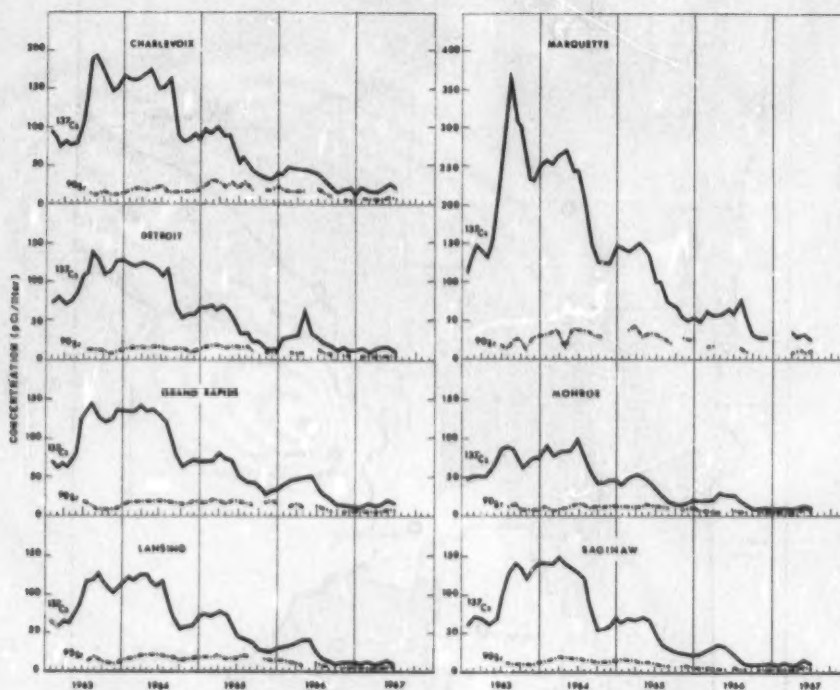


Figure 9. Radionuclide concentrations in Michigan pasteurized milk 1963-June 1967

5. Minnesota Milk Network April-June 1967

*Division of Environmental Health
Minnesota Department of Health*

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds geographically the same as the Minnesota Health districts (figure 10) and analyzed for strontium-90, iodine-131, and cesium-137. One-liter samples of processed Grade A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health Department district offices are located. However, it is sometimes convenient to collect at other

locations. Such samples are considered representative of the district concerned.

Strontium-90 concentrations are determined radiochemically, while iodine-131 and cesium-137 concentrations are determined by gamma-ray scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and the Rural Cooperative Power Association (6).

Strontium-90 and cesium-137 concentrations in milk are given for April through June 1967 in table 5, and are presented graphically by milkshed in figure 11 for the period 1961 through June 1967. Iodine-131 concentrations were less than 10 pCi/liter in all 24 samples.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	May 1967
January-March 1967	August 1967

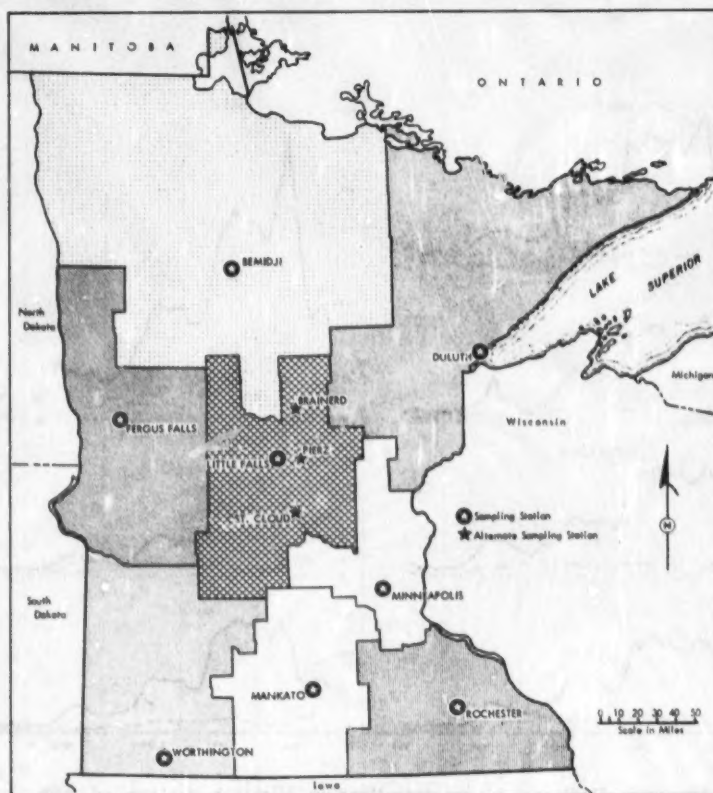


Figure 10. Minnesota milk sampling locations

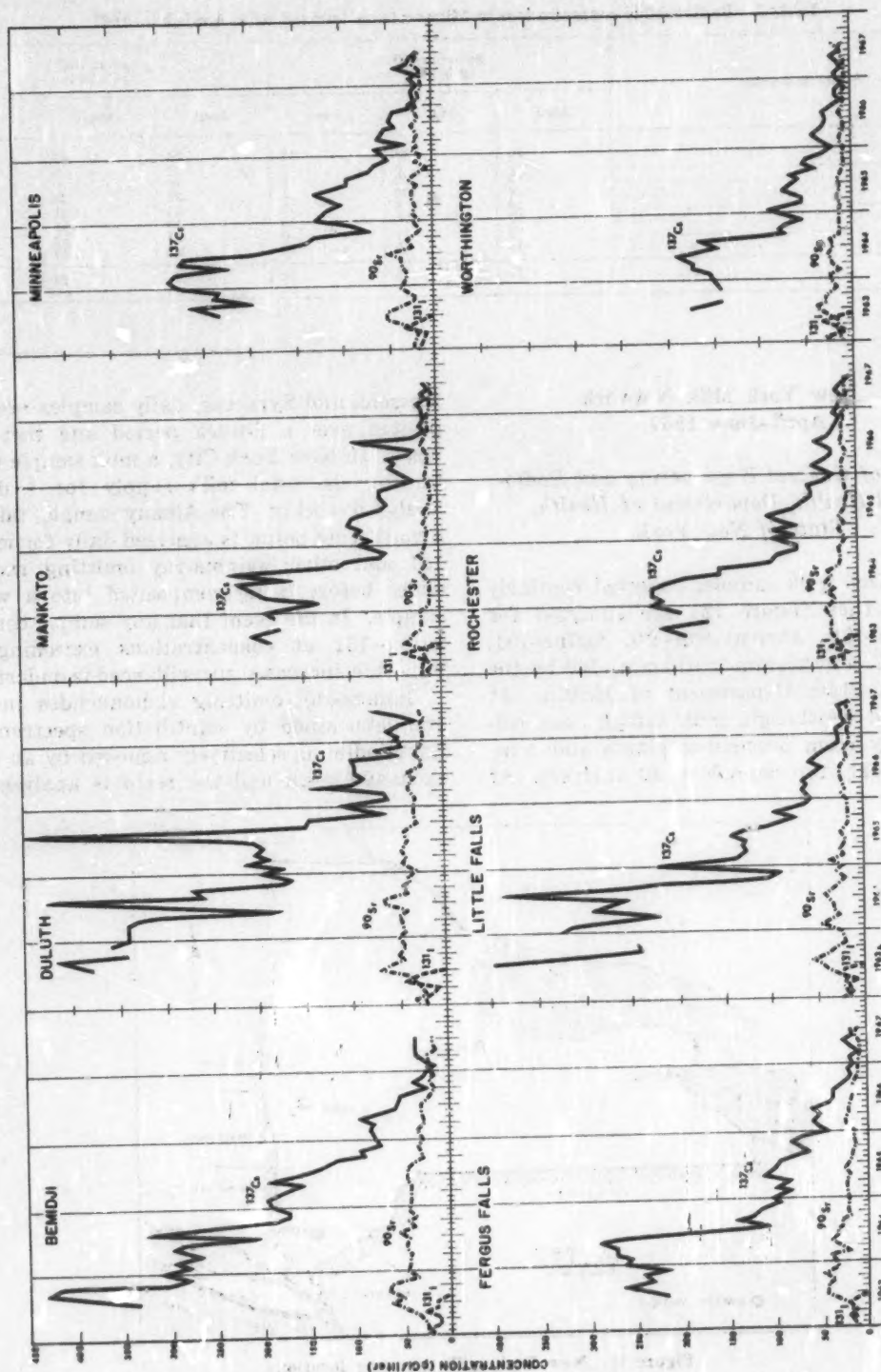


Figure 11. Radionuclide concentrations in Minnesota milk, 1963-June 1967

Table 5. Radionuclide concentrations in Minnesota pasteurized milk, April-June 1967

Sampling location	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	April	May	June	April	May	June
Bemidji.....	16	18	18	36	33	33
Mankato.....	5	8	7	17	8	14
Rochester.....	10	10	10	18	10	7
Duluth.....	18	30	34	22	35	66
Worthington.....	10	8	17	23	11	10
Minneapolis.....	17	16	13	19	17	14
Fergus Falls.....	9	11	9	23	13	13
Little Falls.....	13	15	14	24	26	12
Average.....	12	13	14	23	19	21

6. New York Milk Network April-June 1967

*Division of General Engineering and Radiological Health, Department of Health,
State of New York*

Pasteurized milk samples collected routinely from six cities (figure 12) are analyzed for strontium-89, strontium-90, iodine-131, cesium-137, and barium-lanthanum-140 by the New York State Department of Health. At Buffalo and Newburgh, milk samples are collected daily from processing plants and composited weekly for radiochemical analyses. At

Messena and Syracuse, daily samples are composited over a 2-week period and then analyzed. In New York City, a milk sample representing the total milk supply for 1 day is analyzed weekly. The Albany sample, taken at a marketing point, is analyzed daily for iodine-131 and other gamma-ray emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine-131 at concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-ray emitting radionuclides in milk are determined by scintillation spectrometry. Radioiodine is selectively removed by an anion exchange resin and the resin is analyzed for



Figure 12. New York milk sampling locations

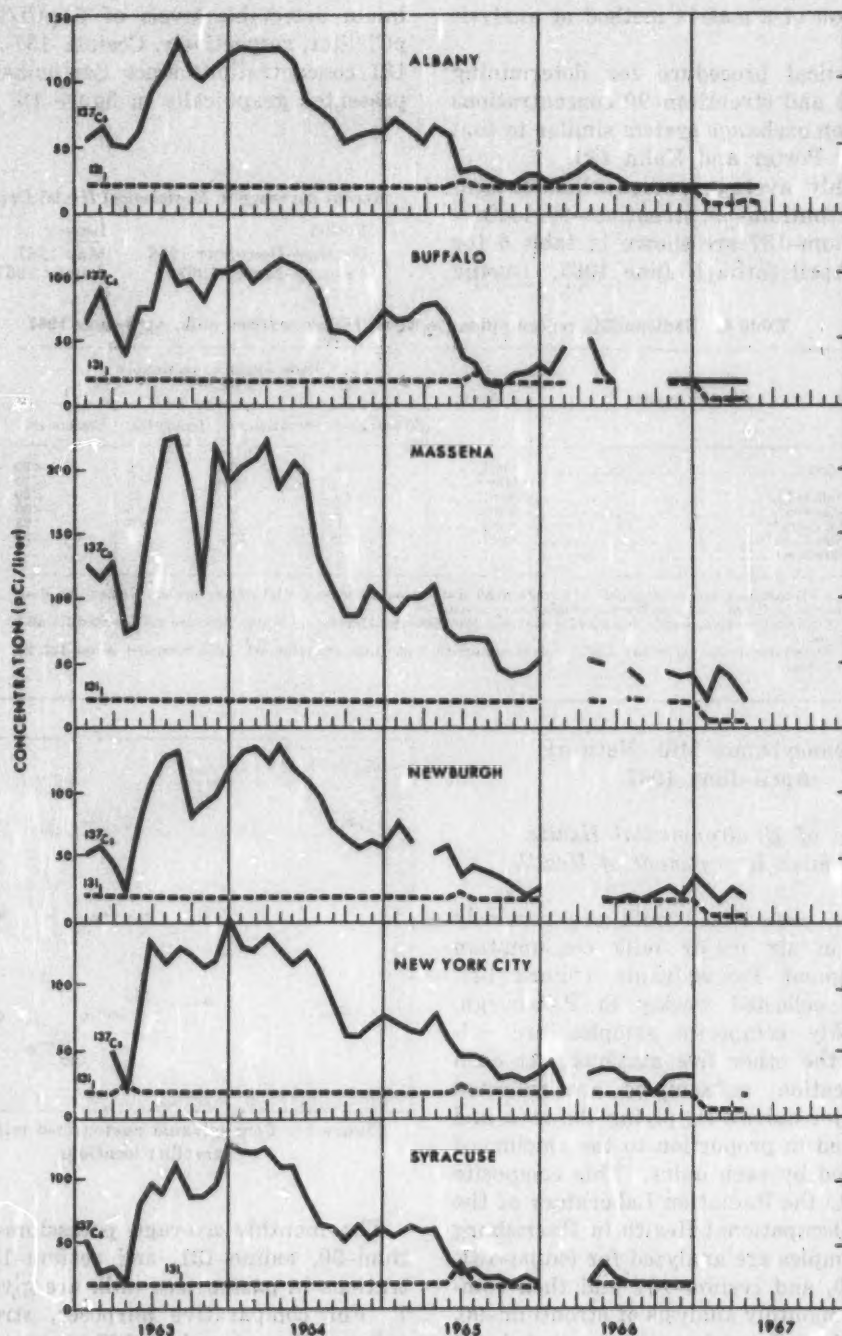


Figure 13. Radionuclide concentrations in New York milk, 1963-June 1967

iodine-131 (7,9). The resin effluent is analyzed and the resulting spectral data is resolved by the application of a matrix method of analysis (8).

The analytical procedure for determining strontium-89 and strontium-90 concentrations employs an ion exchange system similar to that developed by Porter and Kahn (2).

The monthly average radionuclide concentrations of strontium-89, strontium-90, iodine-131, and cesium-137 are shown in table 6 for the period April through June 1967. During

this period, essentially all iodine-131 and strontium-89 concentrations were below their minimum detectable levels of 5 pCi/liter and 3 pCi/liter, respectively. Cesium-137 and iodine-131 concentrations since September 1961 are presented graphically in figure 13.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	May 1967
January-March 1967	August 1967

Table 6. Radionuclide concentrations in New York pasteurized milk, April-June 1967

Sampling location	Month	Radionuclide concentrations (pCi/liter)			
		Strontium-89	Strontium-90	Iodine-131	Cesium-137
Albany	April	<3	16	6	<20
	May ^a			<5	<20
Buffalo ^b	April	<3	6	<5	<20
Massena ^b	April	<3	9	<5	<20
Newburg ^b	April	<3	5	<5	23
New York ^b	April	<3	11	<5	<20
Syracuse ^b	April				

^a No analysis given for May 1967 for strontium-89 or strontium-90 because of laboratory move. No analysis given for the month of June also because of laboratory move.

^b No analysis given for the months May and June 1967 because of laboratory move. Syracuse not reported for all 3 months.

Detectable limits: iodine-131, 5 pCi/liter; strontium-89, 3 pCi/liter; strontium-90, 3 pCi/liter; and cesium-137, 20 pCi/liter.

7. Pennsylvania Milk Network April-June 1967

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from six major milk consumption areas throughout Pennsylvania (figure 14). Samples are collected weekly in Pittsburgh, while biweekly composite samples are collected from the other five stations. At each sampling location, subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the samples are analyzed for iodine-131, potassium-40, and cesium-137 and then composited for a monthly analysis of strontium-90. Strontium-90 analyses have been carried out since April 1963.

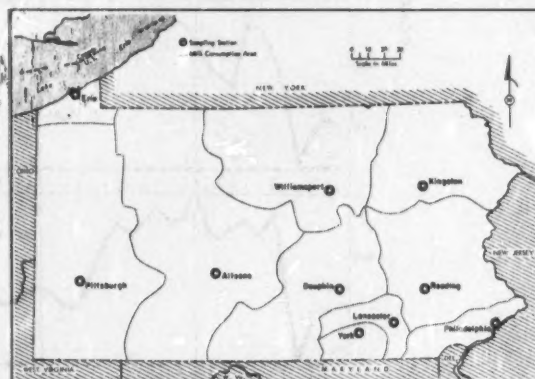


Figure 14. Pennsylvania pasteurized milk network sampling locations

The monthly average potassium-40, strontium-90, iodine-131, and cesium-137 concentrations in pasteurized milk are given in table 7. For comparative purposes, strontium-90, iodine-131, and cesium-137 concentrations are presented graphically in figure 15.

Table 7. Radionuclide concentrations in Pennsylvania pasteurized milk, April-June 1967

Sampling location	Radionuclide concentrations (pCi/liter)											
	Potassium-40			Strontium-90			Iodine-131			Cesium-137		
	April	May	June	April	May	June	April	May	June	April	May	June
Altoona.....	874	889	882	13	13	12	<10	<10	<10	20	18	16
Dauphin.....	819	887	776	10	9	8	<10	<10	ND	12	18	17
Erie.....	901	870	941	17	16	17	ND	ND	<10	23	26	26
Philadelphia.....	902	907	863	11	11	11	ND	<10	ND	16	23	15
Pittsburgh.....	881	883	858	14	19	14	<10	ND	<10	22	21	19
York.....	886	925	887	11	10	9	ND	<10	<10	19	13	16
Average.....	874	885	870	13	13	12	<10	<10	<10	19	20	19

ND, nondetectable.

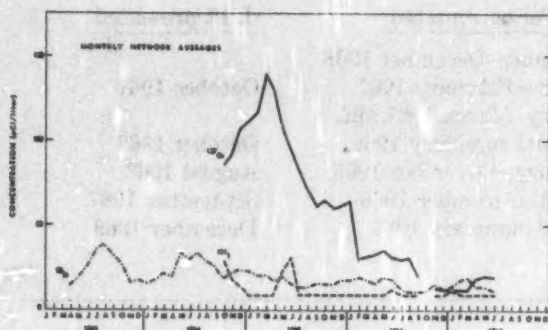


Figure 15. Radionuclide concentrations in Pennsylvania pasteurized milk, 1963-June 1967

The chemical separation technique for strontium-90 is essentially an ion exchange method described by Porter *et al.* (1).

Recent coverage in Radiological Health Data and Reports

Period	Issue
October-December 1966	May 1967
January-March 1967	August 1967

REFERENCES

- (1) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY and B. KAHN. Determination of strontium-90 in milk by an ion-exchange method. *Anal Chem* 33:1306-1308 (September 1961).
- (2) PORTER, C., and B. KAHN. Improved determinations of strontium-90 in milk by an ion-exchange method. *Anal Chem* 36:876-878 (March 1964).
- (3) INDIANA STATE BOARD OF HEALTH, BUREAU OF ENVIRONMENTAL SANITATION. Indiana milk network, April-June 1966. *Radiol Health Data* 6:612-614 (November 1966).
- (4) PORTER, C., R. AUGUSTINE, J. MATUSEK, JR., and M. CARTER. Procedures for determination of stable elements and radionuclides in environmental samples, PHS Publication No. 999-RH-10. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (January 1965).
- (5) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962-December 1964. *Radiol Health Data* 6:487-492 (September 1965).
- (6) MINNESOTA DEPARTMENT OF HEALTH AND RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January-June 1965, COO-615-17 (August 1965).
- (7) JOHNSON, R. H., and T. C. REAVEY. Evaluation of ion exchange cartridges for field sampling of iodine-131 in milk. *Nature* 208:750-752 (November 1965).
- (8) KAHN, B., G. K. MURTHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk, PHS Publication No. 999-R-5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1965).
- (9) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine-131 from milk. *Public Health Rep* 80:453-456 (May 1965).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for devel-

oping estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	September-December 1966	
	January-February 1967	October 1967
Institutional Diet, PHS	January-March 1967 and annual summary 1966	October 1967
Teenage Diet, FDA	February-November 1965	August 1966
Tri-City Diet, HASL	August-December 1966	September 1967
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

1. Estimated Daily Intake of Radionuclides in Connecticut Standard Diet, January-June 1967

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analysis are made for strontium-89, strontium-90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included

milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Cesium-137 concentrations were determined by gamma-ray spectrometry (1). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (1).

Table 2 presents the analytical results for the Connecticut standard diet from January through June 1967. Results representative of the total daily intake for the radionuclides observed are presented in table 3.

In order to evaluate general trends, the

Table 1. Foods included in standard diet

Bread, white—8 slices	Ice cream— $\frac{1}{2}$ pint
Butter $\frac{1}{2}$ stick	Lettuce, washed—4-5 leaves
Carrots, scraped— $\frac{1}{2}$ cup	Milk—3 cups
Celery, washed and trimmed—3 stalks	Oatmeal, uncooked—43 grams
Cookies—4	Orange—1
Cottage cheese— $\frac{1}{2}$ cup	Peanut butter—2 $\frac{1}{2}$ tablespoons
Cupcakes—3	Pears, canned—2 halves with juice
Egg—1	Potatoes, washed, not peeled—2
Green beans, washed— $\frac{1}{2}$ cup	Sugar—5 tablespoons
Ham—85 grams	Tomato juice—113 grams
Hamburger—227 grams	Tuna fish, drained—43 grams

Table 2. Radionuclide concentrations in Connecticut standard diet, January-June 1967 *

Month (1967)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
January.....	2.4	10	30
February.....	2.3	9	30
March.....	NS	NS	NS
April.....	2.3	10	30
May.....	2.2	8	10
June.....	2.1	11	30

* All strontium-90 values were <3 for this period. NS, no sample collected.

Table 3. Daily radionuclide intakes in Connecticut standard diet, January-June 1967 *

Month (1967)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
January	7.7	33	100
February	7.1	26	80
March	NS	NS	NS
April	7.1	31	90
May	6.7	25	40
June	6.6	33	60

* All strontium-90 values were <3 for this period. NS, no sample collected.

strontium-90 and cesium-137 daily intakes are plotted as a function of time in figures 1 and 2.

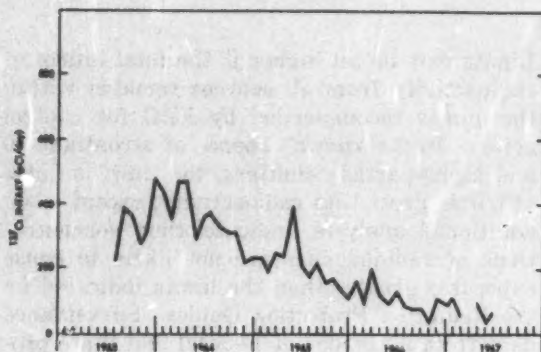


Figure 1. Cesium-137 intake in Connecticut standard diet 1963-June 1967

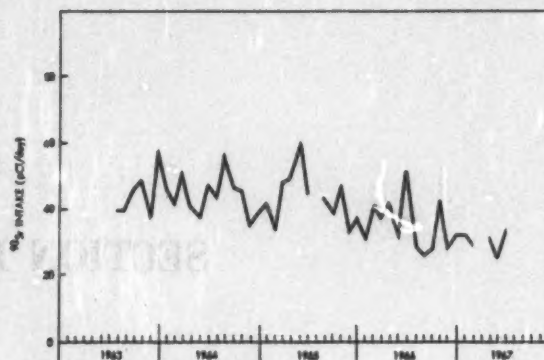


Figure 2. Strontium-90 intake in Connecticut standard diet, 1963-June 1967

REFERENCE

- (1) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963-December 1964. Radiol. Health Data 6:381:382 (July 1965).

Recent coverage in Radiological Health Data and Reports:

Period	Issue
July 1965-June 1966	November 1966
July 1966-December 1967	May 1967

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively.

Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analyses indicate that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Activity	Period reported	Last presented
California Water Sampling Program	January-June 1966	June 1967
Minnesota Surface Water Sampling Program	July-December 1966	October 1967
New York Surface Water Sampling Program	January-December 1966	September 1967
Washington Surface Water Sampling Program	July 1965-June 1966	August 1967

REFERENCES

- (1) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).
- (2) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

- (3) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).
- (4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States May 1967

Division of Pollution Surveillance, Federal
Water Pollution Control Administration,
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1967 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the gross alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total

beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (1-6). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of data for additional comment.

They reflect no public health significance as

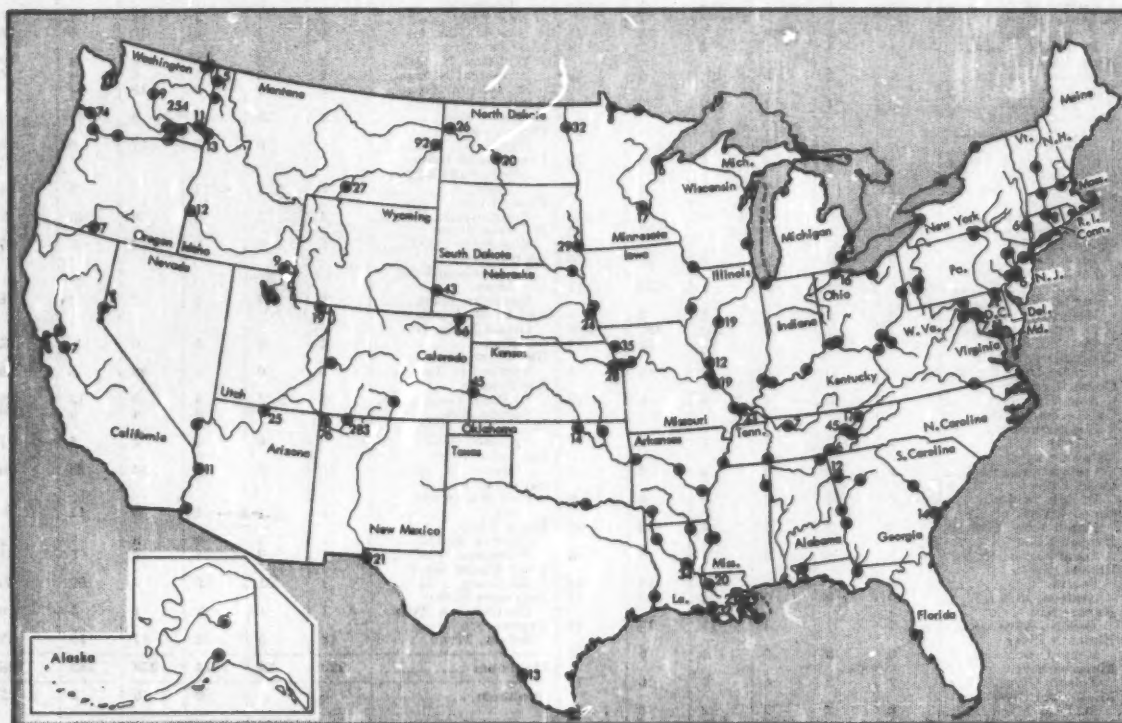


Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, May 1967

the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these high values are significant, comment will be made.

During both April and May, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

In May, Coolidge, Kans., on the Arkansas River showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids. Also, Sidney, Mont., on the Yellowstone River showed alpha radioactivity on suspended solids in excess of 15 pCi/liter.

Table 1. Radioactivity in raw surface waters, May 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)			Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Mississippi River—						
Cedar Hill, N. Mex.	123	1	124	278	5	283	Continued						
Arkansas River:							New Roads, La.	2	1	3	13	7	20
Coolidge, Kans.	2	16	18	9	36	45	New Orleans, La.	5	1	6	17	6	23
Ponca City, Okla.	1	1	2	7	7	14	Missouri River:						
Ateahafalaya River:							Williston, N. Dak.	3	2	5	12	14	26
Morgan City, La.	6	0	6	23	9	32	Bismarck, N. Dak.	2	3	5	5	14	20
Bear River:							St. Joseph, Mo.	3	2	5	18	17	35
Fresno, Idaho.	0	1	1	0	9	9	North Platte River:						
Big Horn River:							Henry, Nebr.	1	32	33	6	37	43
Hardin, Mont.	4	7	11	13	14	27	Ohio River:						
Big Sioux River:							Cairo, Ill.	6	0	6	17	6	23
Sioux Falls, S. Dak.	1	3	4	4	25	29	Pend Oreille River:						
Clearwater River:							Albani Falls Dam,						
Lewiston, Idaho.	2	< 1	2	10	3	13	Idaho.	0	< 1	< 1	1	4	5
Clinch River:							Platte River:						
Clinton, Tenn.	1	0	1	8	3	11	Plattsmouth, Nebr.	4	4	8	9	15	24
Kingston, Tenn.	0	1	1	< 1	45	45	Potomac River:						
Colorado River:							Washington, D.C.	0	0	0	2	5	7
Pago, Ariz.	0	9	9	2	23	25	Rainy River:						
Parker Dam, Calif.							International Falls,						
Ariz.	0	2	2	1	10	11	Minn.						
Columbia River:							Baudette, Minn.	0	0	0	2	6	8
Wenatchee, Wash.	0	5	5	1	8	9	Red River, North:						
Pasco, Wash.	1	1	1	126	182	308	Grand Forks, N.						
Clatskanie, Ore.	1	1	1	22	52	74	Dak.	1	4	5	6	26	32
Connecticut River:							Red River, South:						
Enfield Dam, Conn.	0	0	0	2	6	8	Alexandria, La.	9	0	9	29	5	34
Coosa River:							Rio Grande:						
Rome, Ga.	4	0	4	8	4	12	El Paso, Tex.	2	2	4	9	12	21
Cumberland River:							Laredo, Tex.	1	2	3	4	9	13
Cheatham Lock,							San Joaquin River:						
Tenn.	1	0	1	4	3	7	Vernalis, Calif.	0	0	0	2	5	7
Delaware River:							San Juan River:						
Philadelphia, Pa.	0	0	0	2	4	6	Shiprock, N. Mex.	15	8	23	54	22	76
Great Lakes:							Savannah River:						
Duluth, Minn.	0	0	0	2	4	6	Port Wentworth,						
Green River:							Ga.	1	< 1	1	3	11	14
Dutch John, Utah.	0	3	3	1	18	19	Snake River:						
Hudson River:							Payette, Idaho.	1	3	4	3	9	12
Poughkeepsie, N.Y.	0	0	0	1	5	6	Wawawai, Wash.	1	0	1	6	5	11
Illinois River:							South Platte River:						
Peoria, Ill.	0	1	1	7	12	19	Julesburg, Colo.	1	31	32	7	50	66
Grafton, Ill.	0	0	0	2	10	12	Tennessee River:						
Kansas River:							Chattanooga, Tenn.	< 1	1	1	1	5	6
DeSoto, Kans.	2	2	4	11	17	28	Yellowstone River:						
Klamath River:							Sidney, Mont.	18	5	23	77	15	92
Keno, Ore.	0	0	0	1	6	7	Maximum	123	32	124	276	182	308
Maumee River:							Minimum	0	0	0	0	3	5
Toledo, Ohio.	2	2	4	6	10	16							
Mississippi River:													
St. Paul, Minn.	0	2	2	3	15	17							
E. St. Louis, Ill.	1	1	2	11	8	19							

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Cedar Hill, N. Mex., on the Animas River had a very high suspended solids content in the sample collected on May 9. This high value yielded an average of more than 15 pCi/liter in alpha radioactivity, although the remaining sample values were well below 15 pCi/liter. Pasco, Wash., on the Columbia River continued to show beta radioactivity on dissolved solids in excess of 150 pCi/liter, and Cedar Hill, N. Mex., showed beta radioactivity on suspended solids in excess of 150 pCi/liter.

REFERENCES

- (1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL.

National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

- (2) *Ibid.*, 1959 Edition.

- (3) *Ibid.*, 1960 Edition.

- (4) *Ibid.*, 1961 Edition.

- (5) *Ibid.*, 1962 Edition.

- (6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Radiostrontium in Tap Water, July-December 1966¹

*Health and Safety Laboratory
U.S. Atomic Energy Commission*

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (1).

Strontium-90 concentrations and cesium-137/strontium-90 ratios in New York City tap

water for July through December 1966 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (2).

Table 1. Radiostrontium in New York City tap water July-December 1966

Date	Strontium-90 * (pCi/liter)	Cesium-137/ strontium-90
1966		
July.....	0.92	0.24
August.....	.86	.21
September.....	.82	.19
October.....	.76	.09
November.....	.80	.14
December.....	.86	.07

* Approximately 100 liters per sample.

¹ Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL-182. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

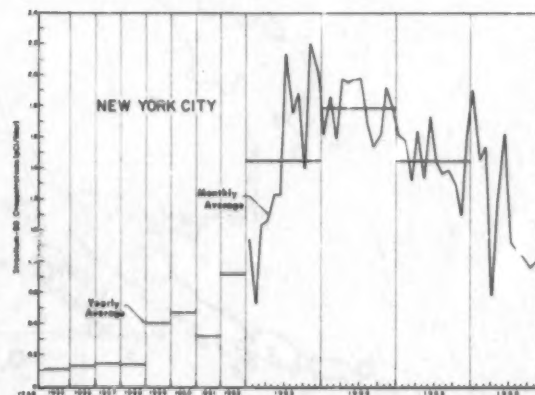


Figure 1. Strontium-90 concentrations in New York City tap water, 1955-December 1966

REFERENCES

- (1) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-32-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N. Y.
- (2) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Sub-

part J, Drinking Water Standards 27:2154-5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in Radiological Health Data and Reports:

Period	Issue
May and July-November 1965	June 1966
November 1965-June 1966	December 1966

Radionuclides Analysis of Coast Guard Water Supplies January-December 1966

*U.S. Coast Guard¹ and National Center for
Radiological Health²*

Beginning in October 1961, 1-gallon samples of water have been obtained from seven Coast Guard Loran Stations in Alaska (figure 1).

¹ U.S. Department of the Treasury.

² U.S. Public Health Service.

The prime source of potable water at the Adak Loran Station is Alpine Lake, which is at an elevation of 1,000 feet. The lake is occasionally frozen over with little snow cover each year from December through April. Water is

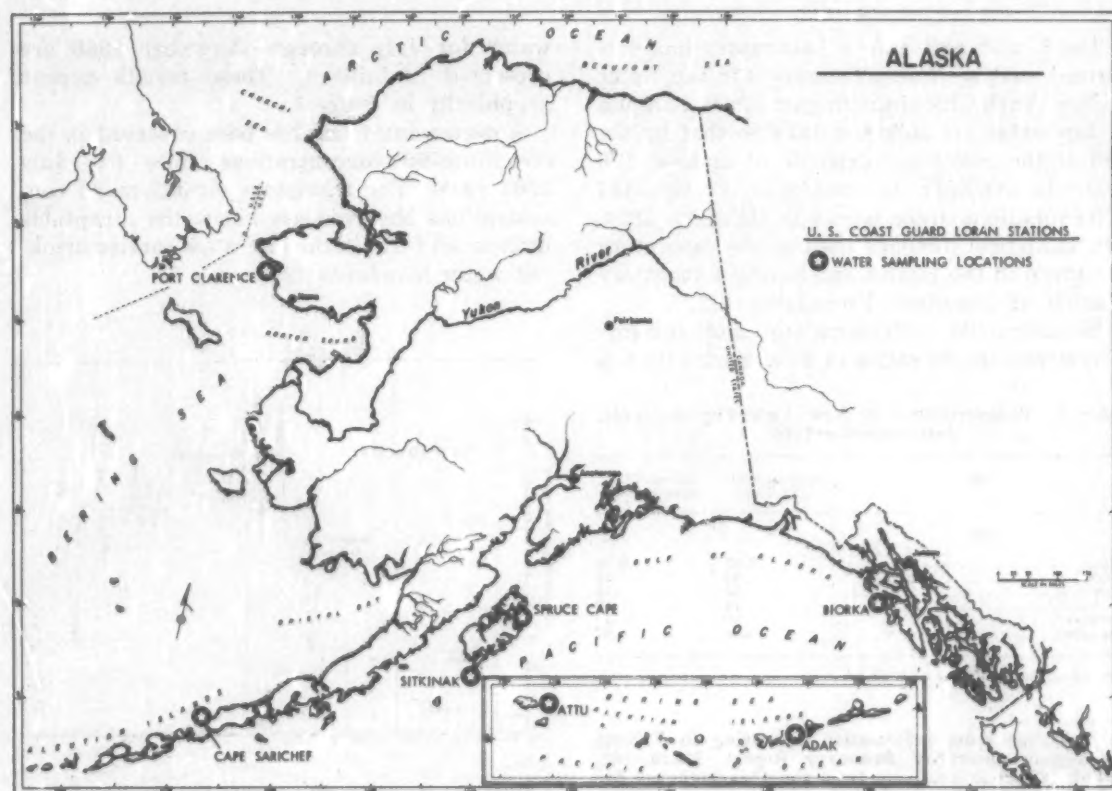


Figure 1. Coast Guard Loran station water sampling locations

delivered from the lake as needed through a 2-mile pipe line to three 25,000-gallon concrete reservoirs. All water is chlorinated at the station before use.

The Attu Loran Station's prime source of potable water is Alout Creek Dam and reservoir. This water source is usually frozen over from November through April, with a frequent snow cover of 1 to 3 feet. A 1-mile pipe line feeds water by gravity to three 25,000-gallon concrete reservoirs at the station. The water is chlorinated before use.

The Biorka Loran Station's water comes from a lake that is often frozen over lightly from January to March. The water is fed by gravity through a 1-mile-long insulated pipe to a pump house. From there it is pumped another mile to a 25,000-gallon steel storage tank from which it is fed by gravity one-half mile to the station, filtered, and chlorinated.

The source of water for the Cape Sarichef Loran Station is a small dammed creek and reservoir. The reservoir is usually frozen over from December through April, with 1 to 3 feet

Table 1. Radioactivity in water samples from U.S. Coast Guard Loran stations January-December 1966

Alaskan location	Collection date 1966	Gross alpha radioactivity (pCi/liter)	Gross beta radioactivity (pCi/liter)
Adak Island	January 14	1.0	8
	February 14	<0.1	6
	April 15	9.0	1
	May 11	<.1	6
	June 17	<.1	6
	September 12	.3	1
	October 12	<.1	1
	November 7	3.0	12
	December 6	<.1	1
Attu Island	January 7	.3	6
	February 3	<.1	6
	March 4	1.4	9
	March 31	.3	10
	April 29	<.1	2
	June 3	.5	1
	July 1	.6	<1
	September 13	<.1	4
	October 11	<.1	1
	November 8	<.1	5
	December 6	<.1	6
Biorka Island	March 14	<.1	5
	May 31	4.5	5
	November 7	<.1	43
	December 6	<.1	18
Cape Sarichef	January 12	5.3	4
	February 12	.3	3
	March 5	<.1	4
	April 8	<.1	3
	April 11	.5	1
	May 10	1.0	5
	June 7	<.1	<1
	July 6	<.1	5
	August 2	.7	<1
	October 6	.7	4
	November 3	<.1	<1
	December 5	<.1	4
Port Clarence	June 15	3.3	22
	September 15	<.1	16
	October 10	<.1	9
	November 9	<.1	11
	December 8	<.1	12
Sitkinak Island	January 15	.7	1
	February 16	.6	3
	March 11	.3	6
	April 18	<.1	5
	September 12	<.1	<1
Sperdy Cape	January 18	.9	1
	February 17	.3	<1
	March 5	.3	1
	May 12	<.1	6
	June 10	<.1	3
	July 8	.2	4
	September 12	.3	<1
	November 3	<.1	5
	December 6	<.1	11
Maximum		9.5	43
Minimum		<0.1	<1

of snow cover during that period. The water is pumped $1\frac{1}{2}$ miles from the dam to a 25,000-gallon steel storage tank above ground, from which the water is fed by gravity to the station, filtered and chlorinated.

The Sitkinak Loran Station obtains its water from a natural lake which is normally frozen over from December through April, with 3 to 12 inches of snow cover during that period. The water is pumped from the lake through a 1,500-foot line to three 25,000-gallon concrete reservoirs at the Station. The water is filtered and chlorinated as used.

Port Clarence Loran Station's source of water is two shallow, flatland lakes, which freeze solid to their depth of $1\frac{1}{2}$ to 3 feet from November through May. A variable snow cover of 1 to 5 feet is normal during this period. The water is pumped beneath the ice and seasonal frost to the station's concrete cisterns of 225,000-gallon capacity. Normally the entire capacity of the station's tanks is topped off prior to December 1 and only a small amount of water is pumped from the lake area after that date, depending on the thickness of snow, ice, and frost cover during the winter months. At the time of the first thaw, usually in May, the station tanks are again filled and kept filled until the following winter freeze. All water is filtered and chlorinated before use.

A natural hillside lake is Spruce Cape Loran Station's source of water. The lake is generally ice-free throughout the entire winter season with only light snowfall and general slush. The water is pumped one-half mile from the lake to a 25,000-gallon wood-stave cistern from which it is fed by gravity to the station, filtered, and chlorinated.

Water samples are analyzed for gross alpha and gross beta radioactivity, barium-lanthanum-140, cesium-137, iodine-131, ruthenium-103, ruthenium-106, and zirconium-niobium-95. The analyses for specific radionuclides are performed by gamma-ray spectrometry. All analyses are performed by the Southwestern Radiological Health Laboratory, Las Vegas, Nev. The results of the gross alpha and beta analyses are reported in table 1. Values for specific radionuclide content are not reported, since in all cases they were below the respective minimum detectable levels (cesium-137, 5 pCi/liter; all others, 10 pCi/liter).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
January-December 1964	November 1965
January-December 1965	November 1966

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the

Western Hemisphere. These include data from the programs of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above programs was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*:

<u>Network</u>	<u>Period</u>	<u>Issue</u>
HASL Fallout Network	July-December 1966	September 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967

1. Radiation Surveillance Network July 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly collects samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analyses. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators. These estimates are made after the decay of radon and thoron daughter products and prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are

promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (1). A detailed description of the sampling and analysis procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during July 1967. Time profiles of gross beta radioactivity in air dating back to 1958 for eight RSN stations are shown in figure 2.

Radioactivity levels in airborne particulates remained near or below the detectability limit. The only precipitation sample more active than the 200 pCi/liter lower reporting limit was collected at Madison, Wisc., on July 31. This sample contained 5,100 pCi/liter gross beta radioactivity extrapolated to the time of collection and deposited 5.5 nCi/m². The sample was not typical of fresh nuclear testing debris in that it emitted no measurable gamma radiation.

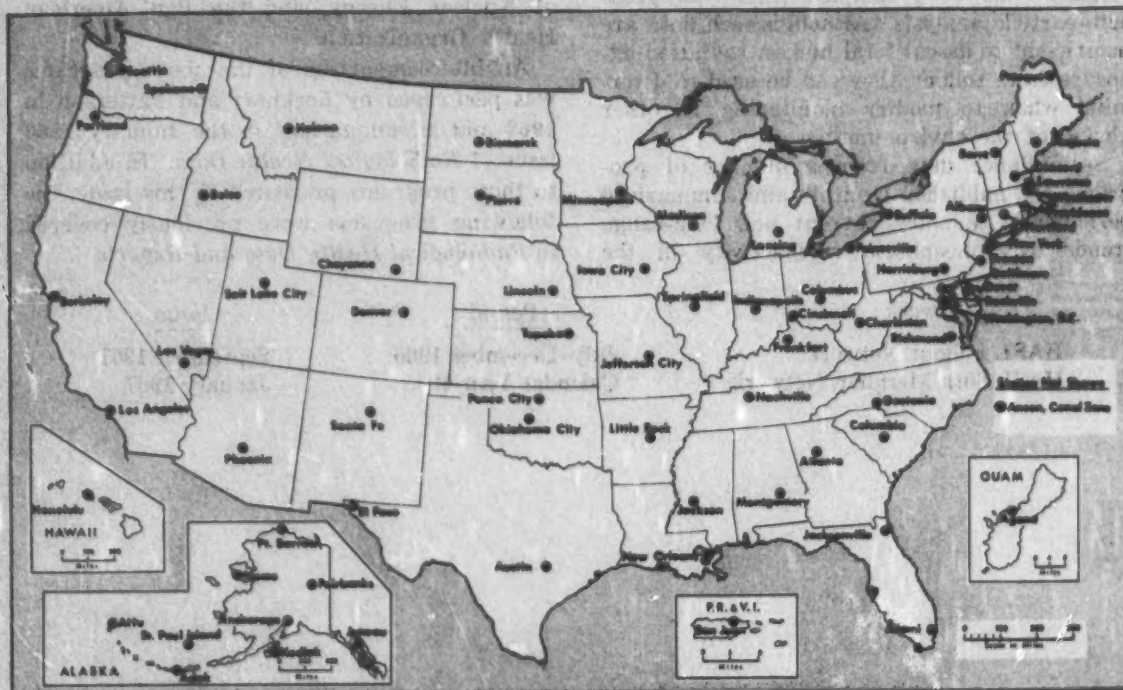


Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, July 1967

Station location		Number of samples		Air surveillance, gross beta radioactivity (pCi/m ³)			Last profile in RND&R	Precipitation	
		Air	Precip	Maximum	Minimum	Average ^a		Total depth (mm)	Total deposition (pCi/m ²)
Ala:	Montgomery	31	9	0.06	0.01	0.06	Nov 67	3.5	<43
Alaska:	Adak	29		0.06	0.00	0.01	June 67	(3)	
	Anchorage	23	9	0.06	0.00	0.01	Dec 66	58	<31
	Attu Island	17		0.01	0.00	0.00	July 67		
	Fairbanks	(*)					Jan 67	23	
	Juneau	31	17	0.03	0.00	0.01	Apr 67	167	<33
	Kodiak	30		0.03	0.00	0.01	May 67	300	
	Nome	9		0.03	0.00	0.01	Sept 67	300	
	Pt. Barrow	29		0.03	0.00	0.00	Aug 67	300	
	St. Paul Island	(*)					Oct 67		
Ariz:	Phoenix	30		0.09	0.02	0.04	Apr 67	3	
Ark:	Little Rock	37	7	0.06	0.00	0.03	Dec 66	187	<37
Calif:	Berkeley	23		0.04	0.00	0.03	May 67		
	Los Angeles	23		0.04	0.01	0.02	Sept 67	300	
C.H:	Ancon	19		0.09	0.00	0.06	May 67		
Colo:	Denver	28	7	0.18	0.03	0.06	May 67	102	<20
Conn:	Hartford	30	11	0.03	0.01	0.03	Apr 67	80	<16
Del:	Doyle	23		0.06	0.01	0.03	Nov 67	3	
D.C:	Washington	30	11	0.05	0.01	0.03	Aug 67	108	<21
Fla:	Jacksonville	31	11	0.04	0.01	0.03	Dec 66	220	<24
	Miami	28	7	0.09	0.01	0.03	Apr 67	130	<24
Ga:	Atlanta	31	10	0.07	0.02	0.04	Oct 67	283	<47
Guam:	Agaña	29		0.46	0.00	0.06	Nov 67	(3)	
Hawaii:	Honolulu	31	1	0.04	0.00	0.03	July 67	34	<7
Idaho:	Boise	31	11	0.12	0.02	0.05	July 67		
Ill:	Springfield	31	7	0.09	0.02	0.04	Aug 67	106	<21
Ind:	Indianapolis	31	7	0.06	0.01	0.03	Oct 67	34	<7
Iowa:	Iowa City	31	8	0.09	0.01	0.05	May 67	96	<19
Kans:	Topeka	31	7	0.07	0.02	0.04	Dec 66	102	<20
Ky:	Frankfort	31	14	0.05	0.02	0.03	Aug 67	102	<20
La:	New Orleans	31	13	0.06	0.00	0.03	Aug 67	181	<38
Maine:	Augusta	31	10	0.04	0.00	0.03	Sept 67	98	<20
	Presque Isle	34	9	0.06	0.01	0.03	May 67	47	<9
Md:	Baltimore	23	5	0.07	0.02	0.04	Apr 67	47	<10
	Rockville	14		0.04	0.01	0.03	July 67	(3)	
Mass:	Lawrence	31	9	0.06	0.00	0.03	Nov 67	74	<15
	Winchester	31	14	0.06	0.01	0.03	June 67	66	<14
Mich:	Lansing	30	8	0.06	0.01	0.03	July 67	34	<7
Minn:	Minneapolis	19	8	0.31	0.01	0.04	Nov 67	98	<14
Miss:	Jackson	30	10	0.06	0.01	0.03	Sept 67	185	<37
Mo:	Jefferson City	31	8	0.13	0.01	0.04	Oct 67	75	<15
Mont:	Helena	30	6	0.12	0.03	0.06	June 67	13	<3
Neb:	Lincoln	30	8	0.07	0.00	0.03	Oct 67	107	<23
Nev:	Las Vegas	31		0.10	0.02	0.04	Jan 67	(3)	
N.H:	Concord	31		0.06	0.01	0.03	Aug 67		
N.J:	Trenton	31	10	0.08	0.01	0.03	Sept 67	50	<12
N. Men:	Santa Fe	31	9	0.14	0.01	0.04	June 67	37	<7
N.Y:	Albany	31	6	0.10	0.03	0.05	Oct 67	49	<10
	Buffalo	30		0.07	0.01	0.03	May 67	(3)	
	New York	29		0.06	0.01	0.02	June 67		
N.C:	Gastonia	31	9	0.07	0.01	0.04	May 67	143	<30
N. Dak:	Bismarck	30	4	0.07	0.01	0.04	Aug 67	14	<3
	Bismarck	30		0.06	0.01	0.03	Nov 67	(3)	
Ohio:	Cincinnati	22	3	0.05	0.02	0.03	Sept 67	45	<9
	Columbus	30	9	0.07	0.01	0.03	Apr 67	105	<21
	Painesville	31	7	0.06	0.01	0.03	July 67	35	<8
Okla:	Oklahoma City	30	9	0.03	0.01	0.01	Apr 67	153	<31
	Ponca City	27		0.07	0.01	0.03	Oct 67	(3)	
Ore:	Portland	31		0.07	0.01	0.03	Oct 67	80	<10
Pa:	Harrisburg	31	9	0.21	0.02	0.06	Sept 67	231	<44
P.R:	San Juan	23	13	0.04	0.01	0.03	July 67	116	<23
R.I:	Providence	30	10	0.04	0.01	0.03	June 67	80	<18
S.C:	Columbia	31	1	0.06	0.02	0.04	Apr 67	10	<2
S. Dak:	Pierre	31		0.06	0.01	0.03	July 67	186	<37
Tenn:	Nashville	31	10	0.05	0.01	0.03	Nov 67	3	<1
Tex:	Austin	31	1	0.25	0.02	0.04	Aug 67	67	<14
	El Paso	31	4	0.37	0.01	0.07	Sept 67	30	<6
Utah:	Salt Lake City	31	11	0.05	0.00	0.03	Dec 66	79	<16
Vt:	Barre	31	10	0.04	0.01	0.03	Dec 66	43	<9
Va:	Richmond	31		0.03	0.00	0.02	Dec 66	(3)	
Wash:	Seattle	31		0.06	0.02	0.04	Nov 67		
	Spokane	31	13	0.06	0.01	0.03	June 67	125	<24
W. Va:	Charleston	31	6	0.13	0.01	0.03	Dec 66	60	<17
Wis:	Madison	31	6	0.15	0.02	0.06	Jan 67	43	<8
Wyom:	Cheyenne	30		0.15	0.02	0.06			
Network summary		1,080	413	0.40	0.00	0.03		90	<18

^a The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

^b No precipitation sample collected.

^c No report received.

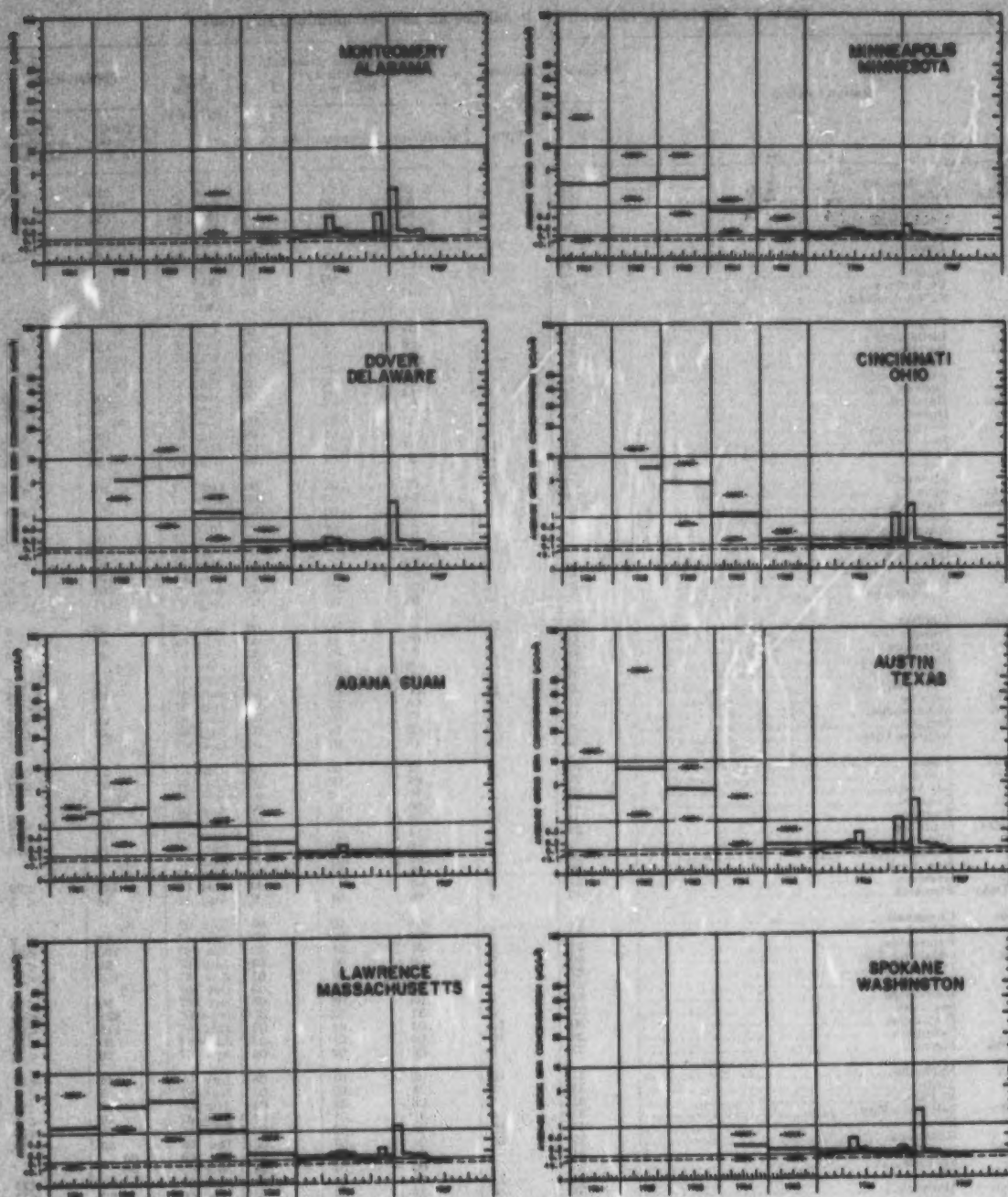


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1963-July 1967

2. Canadian Air and Precipitation Monitoring Program, July 1967

Radiation Protection Division, Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (2-6).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

¹ Prepared from information and data in the August 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for July 1967 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, July 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nC/m ²)
Calgary.....	31	0.1	0.0	0.0	57	0.4
Coral Harbour.....	28	0.0	0.0	0.0	33	0.6
Edmonton.....	31	0.1	0.0	0.0	45	1.5
Pt. Churchill.....	31	0.0	0.0	0.0	5	0.4
Pt. William.....	31	0.1	0.0	0.0	18	1.0
Fredericton.....	31	0.0	0.0	0.0	18	1.3
Goose Bay.....	31	0.0	0.0	0.0	9	1.1
Halifax.....	31	0.0	0.0	0.0	8	1.1
Inuvik.....	31	0.0	0.0	0.0	18	0.6
Montreal.....	31	0.1	0.0	0.0	14	1.0
Moosonee.....	31	0.0	0.0	0.0	15	1.5
Ottawa.....	31	0.0	0.0	0.0	10	1.5
Quebec.....	31	0.0	0.0	0.0	11	1.0
Regina.....	31	0.4	0.0	0.3	85	0.4
Resolute.....	31	0.0	0.0	0.0	6	0.4
St. John's, Nfld.....	31	0.0	0.0	0.0	28	0.9
Saskatoon.....	31	0.0	0.0	0.0	43	0.9
Sault Ste. Marie.....	31	0.1	0.0	0.0	36	1.1
Toronto.....	31	0.1	0.0	0.0	18	1.3
Vancouver.....	31	0.0	0.0	0.0	27	0.6
Whitehorse.....	31	0.0	0.0	0.0	12	0.6
Windsor.....	31	0.1	0.0	0.0	34	1.5
Winnipeg.....	31	0.1	0.0	0.0	13	1.5
Yellowknife.....	31	0.0	0.0	0.0	40	0.6
Network summary....	741	0.4	0.0	0.0	24	1.0



Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program July 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department

of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average radioactivity at each station (?).

The maximum, minimum, and average beta-particle concentrations detected in surface air during July 1967 are presented in table 4.

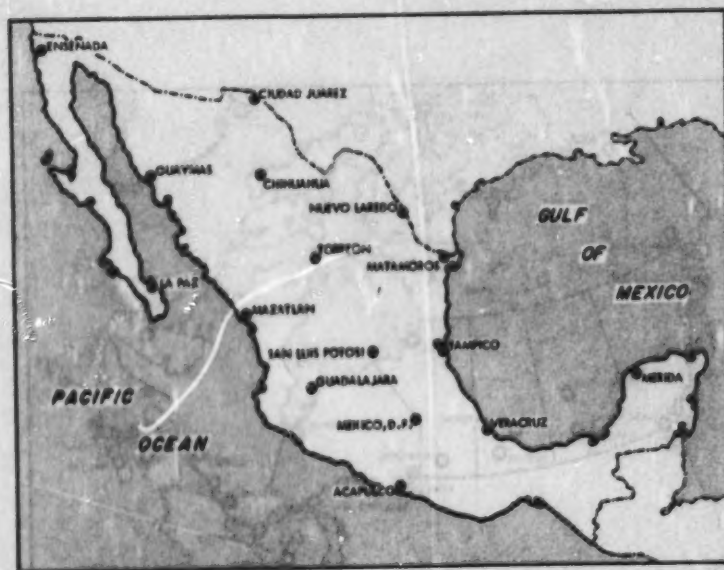


Figure 4. Fallout network sampling stations in Mexico

Table 4. Mexican gross beta radioactivity of airborne particulates, July 1967

Station	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average
Acapulco	3	0.1	0.1	0.1
Chihuahua	3	0.1	0.1	0.1
Ciudad Juarez	1	< .1	< .1	< .1
Guatemala	6	.1	< .1	< .1
Guadalajara	NS			
Guaymas	NS			
La Paz	7	.1	< .1	< .1
Matamoros	NS			
Monterrey	1	< .1	< .1	
Mérida	NS			
México, D. F.	4	.1	.1	.1
Nuevo Laredo	10	.1	.1	.1
San Luis Potosí	NS			
Tampico	13	.1	< .1	< .1
Torresón	9	.1	< .1	< .1
Veracruz	8	.1	< .1	< .1

NS, no sample collected, station temporarily shut down.

4. Pan American Air Sampling Program July 1967

*Pan American Health Organization and
U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in the developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling locations are shown in figure 5.

The July 1967 air monitoring results are given in table 5. Increases in airborne gross beta radioactivity occurred in all reporting stations south of the equator. Those samples more active than 1.0 pCi/m³ at the time of collection are presented in table 6.



Figure 5. Pan American Air Sampling Program stations

Table 5. PAHO gross beta radioactivity in surface air July 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires.....	7	0.30	0.03	0.13
Bolivia: La Paz.....	15	29.01	.03	3.37
Chile: Santiago.....	31	1.33	.00	.30
Colombia: Bogota.....	20	.99	.00	.12
Ecuador: Guayaquil.....	20	0.31	.00	1.08
Jamaica: Kingston.....	21	.04	.01	.06
Peru: Lima.....	25	12.97	.04	3.37
Venezuela: Caracas.....	16	.34	.00	.04
West Indies: Trinidad.....	21	.35	.00	.04
Pan American summary.....	183	29.01	0.00	0.78

* The monthly average is calculated by weighting the individual samples with length of sampling period.

Table 6. Samples from PAHO member countries which contained radioactivity greater than 1 pCi/m³

Location	Date July 1967	Gross beta radioactivity at collection (pCi/m ³)
Peru: Lima.....	13	3.18
	14	4.73
	15	4.40
	16-17	9.37
	18	13.97
	19	10.13
	20	5.08
	21	1.81
Chile: Santiago.....	15	1.11
	16	3.33
Ecuador: Guayaquil.....	15-17	9.31
	18	5.00
	19	7.38
	20	2.36
Bolivia: La Paz.....	4	29.01
	5	23.00
	13	3.97
	25	1.30

5. Plutonium in Airborne Particulates and Precipitation and Strontium-90 in Precipitation, April-June 1967

National Center for Radiological Health
U.S. Public Health Service

The Radiation Surveillance Network (RSN) of the National Center for Radiological Health, Public Health Service, located at Rockville, Md., performs analyses of airborne particulates and precipitation samples, collected at several geographically selected RSN stations, for total

Table 7. Plutonium in airborne particulates April-June 1967

Sampling location	Plutonium content * (pCi/1,000m ³)		
	April	May	June
Alaska: Anchorage.....	0.003	0.048	0.029
Ariz: Phoenix.....	.100	.146	.057
Calif: San Francisco.....	.143	.076	.082
Hawaii: Honolulu.....	.067	.045	.047
Id: Boise.....	.088	.087	.062
La: New Orleans.....	.117	.101	.057
N.Y.: Buffalo.....	.222	.289	.091
N.C.: Gastonia.....	.154	.096	.058
S. Dak: Pierre.....	.079	.077	.073
Tex: Austin.....	.101	.085	.094
Wash: Seattle.....	.040	.048	.038

* Plutonium includes ²³⁹Pu, ²⁴⁰Pu and ²⁴¹Pu.

Table 8. Plutonium and strontium-90 in precipitation, April-June 1967

	Station location							
	Denver	Honolulu	New Orleans	Rockville	Gastonia	Pierre	Austin	Seattle
Precipitation depth (mm)								
April.....	86.3	25.0	12.3	45.3	42.3	32.6	26.4	90.3
May.....	72.3	65.0	82.7	66.7	125.3	39.6	77.3	12.0
June.....	113.4	0.0	82.6	45.6	121.4	154.4	77.0	24.6
Total plutonium * (pCi/liter)								
April.....	0.004	0.001	0.003	0.000	0.011	(^c)	.011	0.001
May.....	.009	.010	.018	.015	.013	(^c)	.013	(^c)
June.....	.013	(^c)	.010	.021	.019	0.004	(^c)	.012
Total plutonium * (pCi/m ³)								
April.....	4.77	1.07	.33	1.30	.45	(^c)	.93	.67
May.....	3.13	.90	1.01	1.17	1.72	(^c)	1.43	(^c)
June.....	1.28	(^c)	.80	.83	2.33	3.63	(^c)	.23
Strontium-90 (pCi/liter)								
April.....	9.70	2.13	.33	.88	4.09	(^c)	1.20	1.73
May.....	2.70	.28	1.49	2.30	2.20	(^c)	1.08	(^c)
June.....	2.56	(^c)	.67	.77	.67	1.67	(^c)	1.06
Strontium-90 (pCi/m ³)								
April.....	886.0	110.8	7.0	25.6	171.7	(^c)	103.7	104.1
May.....	272.0	29.6	86.4	180.3	350.3	(^c)	128.9	(^c)
June.....	260.6	(^c)	86.3	50.7	168.6	242.4	(^c)	26.6

* Plutonium includes ²³⁹Pu, ²⁴⁰Pu and ²⁴¹Pu.
^c is sufficient sample for analysis.

plutonium content and also analyzes the precipitation samples for strontium-90. The airborne particulate analyses were initiated in 1965. Details of collection, analysis, and results through March 1967 have been previously reported (8-12). Precipitation analysis began in August 1966 and the results thereof, together with the techniques employed were recently presented (13).

The results for April through June 1967 are presented in tables 7 and 8.

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- (8) **RUSSELL, J., H. LEVINE, R. SCHNEIDER.** Plutonium in airborne particulates, November 1965 through March 1966. Radiol Health Data Rep 7:482-494 (August 1966).
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- (13) **LEVINE, H., W. P. KIRK, H. J. L. RECHEN.** Plutonium and strontium-90 in precipitation, August 1966 through March 1967. Radiol Health Data Rep 8:574-576 (October 1967).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in previous sections. Included are such data as those obtained from

human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Vertebrae, 1966

Health and Safety Laboratory¹ Atomic Energy Commission

One problem that concerns the Health and Safety Laboratory is the estimation of the radiation dose to man from fallout from nuclear weapons tests. To aid in the solution of this problem, several related studies have been undertaken by the laboratory. One of these is the systematic long-term determination of the strontium-90 content of human bone. Results of the strontium-90 analyses of foods have been published regularly and a summary of the data available through 1963 was given in an earlier report (1). A summary of the bone sampling program through 1964 together with an interpretation of the relationship between diet and bone levels was given in a previous publication (2). Summaries of the results of diet studies for 1964 and 1965 are found in reference (3). The results of the bone sampling program during 1965 have been presented elsewhere (4).

Results of the analyses of specimens obtained during 1966 are listed in tables 1 and 2 and are graphically shown in figure 1. As in previous years, vertebrae from New York City have about twice the strontium-90 concentrations found in vertebrae from San Francisco. In general, the distribution of strontium-90 concentrations with age is also similar to that observed in previous years, i.e., the concentrations in bones from the younger children are greater than those in specimens from older individuals. More specifically, during 1965 and 1966 peak strontium-90 concentrations were observed in children of ages 1 to 2 and 2 to 3 at death while in previous years (1961-64) peak concentrations were found in children 0 to 1 year of age at death. This shift in peak concentrations to older children is to be expected when diet strontium-90 concentrations are declining as has been the case during 1965 and 1966. Fallout from the Chinese thermonuclear weapon detonated in June 1967 may be sufficient to just check the downward trend in diet strontium-90/calcium ratios and therefore this shift in peak strontium-90 bone levels to older ages may not be evident in samples obtained during late 1967 and early 1968.

¹ Material authored by Mr. J. Rivera, from *Fallout Quarterly Summary Report, HASL-182, July 1, 1967*. Available from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Va. 22161.

Table 1. Strontium-90/calcium ratios in human vertebrae
New York City, 1966

Age	Strontium-90/calcium (pCi/g)	Number of specimens	Average
<1 mo	4.30 (3)*	3	4.33
1 mo-1 yr	4.43 (2)	2	7.04
1-2	7.04 (2)	2	6.35
2-4	6.35 (2)	2	5.00
4-6	5.00 (2)	2	4.70
6-7	4.70 (2)	2	3.31
7-8	3.31 (2)	2	3.17
8-9	3.17 (2)	2	3.21
9-10	3.21 (2)	2	3.07
10-11	3.07 (2)	2	3.75
11-12	3.75 (2)	2	3.90
12-13	3.90 (2)	2	3.54
13-14	3.54 (2)	2	3.10
14-15	3.10 (2)	2	3.00
15-16	3.00 (2)	2	3.04
16-17	3.04 (2)	2	3.10
17-18	3.10 (2)	2	3.10
18-19	3.10 (2)	2	3.10
19-20	3.10 (2)	2	3.10
20-21	3.10 (2)	2	3.10
21-22	3.10 (2)	2	3.10
22-23	3.10 (2)	2	3.10
23-24	3.10 (2)	2	3.10
24-25	3.10 (2)	2	3.10
25-26	3.10 (2)	2	3.10
26-27	3.10 (2)	2	3.10
27-28	3.10 (2)	2	3.10
28-29	3.10 (2)	2	3.10
29-30	3.10 (2)	2	3.10
30-31	3.10 (2)	2	3.10
31-32	3.10 (2)	2	3.10
32-33	3.10 (2)	2	3.10
33-34	3.10 (2)	2	3.10
34-35	3.10 (2)	2	3.10
35-36	3.10 (2)	2	3.10
36-37	3.10 (2)	2	3.10
37-38	3.10 (2)	2	3.10
38-39	3.10 (2)	2	3.10
39-40	3.10 (2)	2	3.10
40-41	3.10 (2)	2	3.10
41-42	3.10 (2)	2	3.10
42-43	3.10 (2)	2	3.10
43-44	3.10 (2)	2	3.10
44-45	3.10 (2)	2	3.10
45-46	3.10 (2)	2	3.10
46-47	3.10 (2)	2	3.10
47-48	3.10 (2)	2	3.10
48-49	3.10 (2)	2	3.10
49-50	3.10 (2)	2	3.10
50-51	3.10 (2)	2	3.10
51-52	3.10 (2)	2	3.10
52-53	3.10 (2)	2	3.10
53-54	3.10 (2)	2	3.10
54-55	3.10 (2)	2	3.10
55-56	3.10 (2)	2	3.10
56-57	3.10 (2)	2	3.10
57-58	3.10 (2)	2	3.10
58-59	3.10 (2)	2	3.10
59-60	3.10 (2)	2	3.10
60-61	3.10 (2)	2	3.10
61-62	3.10 (2)	2	3.10
62-63	3.10 (2)	2	3.10
63-64	3.10 (2)	2	3.10
64-65	3.10 (2)	2	3.10
65-66	3.10 (2)	2	3.10
66-67	3.10 (2)	2	3.10
67-68	3.10 (2)	2	3.10
68-69	3.10 (2)	2	3.10
69-70	3.10 (2)	2	3.10
70-71	3.10 (2)	2	3.10
71-72	3.10 (2)	2	3.10
72-73	3.10 (2)	2	3.10
73-74	3.10 (2)	2	3.10
74-75	3.10 (2)	2	3.10
75-76	3.10 (2)	2	3.10
76-77	3.10 (2)	2	3.10
77-78	3.10 (2)	2	3.10
78-79	3.10 (2)	2	3.10
79-80	3.10 (2)	2	3.10
80-81	3.10 (2)	2	3.10
81-82	3.10 (2)	2	3.10
82-83	3.10 (2)	2	3.10
83-84	3.10 (2)	2	3.10
84-85	3.10 (2)	2	3.10
85-86	3.10 (2)	2	3.10
86-87	3.10 (2)	2	3.10
87-88	3.10 (2)	2	3.10
88-89	3.10 (2)	2	3.10
89-90	3.10 (2)	2	3.10
90-91	3.10 (2)	2	3.10
91-92	3.10 (2)	2	3.10
92-93	3.10 (2)	2	3.10
93-94	3.10 (2)	2	3.10
94-95	3.10 (2)	2	3.10
95-96	3.10 (2)	2	3.10
96-97	3.10 (2)	2	3.10
97-98	3.10 (2)	2	3.10
98-99	3.10 (2)	2	3.10
99-100	3.10 (2)	2	3.10

* Parentheses indicate number of individual samples in the composite.

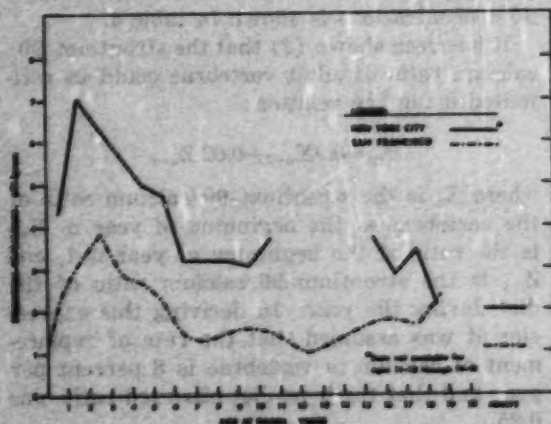


Figure 1. Strontium-90/calcium ratios in human vertebrae, 1966

Table 2. Strontium-90/calcium ratios in human vertebrae
San Francisco, 1966

Age	Strontium-90/calcium (pCi/g)	Number of specimens	Average
<1 mo	1.14 (4)* 1.37 (5) 1.37 (5) 0.98 (3) 2.29 (3) 2.13 (3) 3.20 (3) 1.34 (2) 2.27 (2) 3.27 (2) 3.81 (2)	18	1.18
1 mo-1 yr	1.98 2.81	2	3.35
1-2	2.81	4	3.07
2-3	1.98	2	3.81
3-4	2.81 2.81 2.78 2.18	4	3.90
4-5	2.81 3.43 1.83	3	3.73
5-6	2.30	1	3.30
6-7	1.46 1.31 1.71	2	1.98
7-8	0.98	2	1.31
8-9	1.46	1	1.46
9-10	1.46	1	1.98
10-11	1.46	1	1.46
11-12	0.98	3	1.31
12-13	0.98	1	0.98
13-14	1.77 3.81	2	3.30
14-15	1.70	1	1.70
15-16	1.70	1	1.70
16-17	3.35	1	3.35
17-18	1.46	3	1.43
18-19	1.46	2	1.37
19-20	1.46	2	1.37
20-21	1.46	2	1.37
21-22	1.46	2	1.37
22-23	1.46	2	1.37
23-24	1.46	2	1.37
24-25	1.46	2	1.37
25-26	1.46	2	1.37
26-27	1.46	2	1.37
27-28	1.46	2	1.37
28-29	1.46	2	1.37
29-30	1.46	2	1.37
30-31	1.46	2	1.37
31-32	1.46	2	1.37
32-33	1.46	2	1.37
33-34	1.46	2	1.37
34-35	1.46	2	1.37
35-36	1.46	2	1.37
36-37	1.46	2	1.37
37-38	1.46	2	1.37
38-39	1.46	2	1.37
39-40	1.46	2	1.37
40-41	1.46	2	1.37
41-42	1.46	2	1.37
42-43	1.46	2	1.37
43-44	1.46	2	1.37
44-45	1.46	2	1.37
45-46	1.46	2	1.37
46-47	1.46	2	1.37
47-48	1.46	2	1.37
48-49	1.46	2	1.37
49-50	1.46	2	1.37
50-51	1.46	2	1.37
51-52	1.46	2	1.37
52-53	1.46	2	1.37
53-54	1.46	2	1.37
54-55	1.46	2	1.37
55-56	1.46	2	1.37
56-57	1.46	2	1.37
57-58	1.46	2	1.37
58-59	1.46	2	1.37
59-60	1.46	2	1.37
60-61	1.46	2	1.37
61-62	1.46	2	1.37
62-63	1.46	2	1.37
63-64	1.46	2	1.37
64-65	1.46	2	1.37
65-66	1.46	2	1.37
66-67	1.46	2	1.37
67-68	1.46	2	1.37
68-69	1.46	2	1.37
69-70	1.46	2	1.37
70-71	1.46	2	1.37
71-72	1.46	2	1.37
72-73	1.46	2	1.37
73-74	1.46	2	1.37
74-75	1.46	2	1.37
75-76	1.46	2	1.37
76-77	1.46	2	1.37
77-78	1.46	2	1.37
78-79	1.46	2	1.37
79-80	1.46	2	1.37
80-81	1.46	2	1.37
81-82	1.46	2	1.37
82-83	1.46	2	1.37
83-84	1.46	2	1.37
84-85	1.46	2	1.37
85-86	1.46	2	1.37
86-87	1.46	2	1.37
87-88	1.46	2	1.37
88-89	1.46	2	1.37
89-90	1.46	2	1.37
90-91	1.46	2	1.37
91-92	1.46	2	1.37
92-93	1.46	2	1.37
93-94	1.46	2	1.37
94-95	1.46	2	1.37
95-96	1.46	2	1.37
96-97	1.46	2	1.37
97-98	1.46	2	1.37
98-99	1.46	2	1.37
99-100	1.46	2	1.37

* Parentheses indicate number of individual samples in composite.

Quality control

The accuracy of the radiochemical analyses performed on samples obtained during 1966 may be judged from the quality control data in table 3. The precision of the analyses estimated from the quality control results for 12 blind duplicates is ± 10 percent. The routine analyses of seven blank samples showed that there was no low-level contamination. All unknown samples analyzed had activities well above the routine minimum detectable radioactivity of from 0.1 to 0.2 disintegrations per minute per gram of ash, which corresponds to a strontium-90/calcium ratio of about 0.2 pCi/g calcium. The accuracy of the analyses as judged by the analyses of seven secondary standards was acceptable. Taking all factors into consideration the overall accuracy of a single analysis of a human bone specimen performed during 1966 is estimated to be about ± 10 percent.

Table 2. Quality control samples—bone program, 1968
(dpm strontium-90/g ash)

Splits ^a	Blanks ^b	Standards ^c
2.0 ± .08 ^d	<0.05	5407 1.0 ± 0.01 ^d
1.5 ± .01	.04 ± .01 ^d	5407 1.1 ± .01
1.0 ± .01	<.07	5407 1.1 ± .01
0.9 ± .01	.08 ± .04	5407 .75 ± .08
1.0 ± .01	.03 ± .01	5407 .98 ± .08
3.94 ± .03	<.08	B0126 12.5 ± .04
3.39 ± .03	<.11	B0126 16.7 ± .04
1.1 ± .01		
.9 ± .01		
2.07 ± .03		
3.17 ± .03		
3.38 ± .03		
1.96 ± .03		
.7 ± .01		
.8 ± .01		
1.5 ± .01		
1.4 ± .01		
1.35 ± .04		
1.30 ± .04		
3.16 ± .10		
3.80 ± .11		
2.74 ± .07		
3.08 ± .09		

^a From these results the estimated standard deviation of a single measurement is ± 10 percent.

^b Negative net count rates are reported as ≤ the counting error (1 standard deviation).

^c Previous results obtained on these two samples were:

B0126—13.1 ± 1.4 (69 analyses)

5407—1.05 ± 0.13 (61 analyses)

^d Counting error at 1 standard deviation.

Calculated and observed values

Although the accuracy of analyses is estimated to be within ± 10 percent, the sampling errors are probably much greater. The average values listed in tables 1 and 2 for each age group are, however, probably valid for those groups where many specimens have been represented, i.e., for the 0 to 1 year group and for adults.

The following formula for predicting the strontium-90/calcium ratios of infant bones was derived in an earlier report (2).

$$X = 0.2 Z$$

where X is the average strontium-90/calcium ratio of infant bones during a year in which the diet had a strontium-90/calcium ratio of Z. In deriving the formula it was assumed that Z was not changing rapidly with time. An improvement in the formula is achieved by considering the strontium-90/calcium ratio of an infant at birth in January to be one-tenth the strontium-90/calcium ratio of the diet for October, November, and December (assuming

the mother's diet during the last trimester of pregnancy was not different from that of the general population). The strontium-90/calcium ratio of an infant at the end of the first year of life is assumed to be given by the equation (2):

$$X_1 = \frac{20(X_0) - 30(X_0)(f) + 30(f)(K)(Z) + 70(K)(Z)}{100}$$

where, X_0 = the strontium-90/calcium ratio at birth, f is the fractional replacement of calcium during the year, K is the bone-diet observed ratio, Z is the strontium-90/calcium ratio of the child's diet during the year (assumed here to be the same as the general diet) and the calcium content of the skeleton is assumed to increase from 30 grams at birth to 100 grams at 1 year of age.

Taking $X_0 = 0.10 Z_m$, where Z_m is the average strontium-90/calcium ratio of the diet for October, November and December of the preceding year, $f = 0.50$ and $K = 0.35$, the average strontium-90/calcium ratio of infant bones during the first year of life should be given by:

$$X_{0-1} = \frac{X_0 + X_1}{2} = \frac{0.10 Z_m + 0.03 Z_m + 0.30 Z}{2}$$

$$X_{0-1} = 0.065 Z_m + 0.15 Z$$

A comparison of calculated and observed values obtained using this relation and data obtained since 1962 on diet and bone strontium-90 concentrations is shown in table 4.

It has been shown (2) that the strontium-90/calcium ratio of adult vertebrae could be estimated using the relation:

$$X_n = 0.9 X_{n-1} + 0.02 Z_{n-1}$$

where X_n is the strontium-90/calcium ratio of the vertebrae at the beginning of year n , X_{n-1} is the ratio at the beginning of year $n-1$, and Z_{n-1} is the strontium-90/calcium ratio of the diet during the year. In deriving this expression it was assumed that the rate of replacement of calcium in vertebrae is 8 percent per year and that the bone-diet observed ratio was 0.25.

Since the observed adult strontium-90/calcium ratios used in calculations are average

Table 4. Calculated and observed strontium-90/calcium ratios in infant bone during the first year of life

Year	New York City				San Francisco			
	Z	$\bar{X}_n$	$\bar{X}_{n-1}$		$\bar{X}_n$	$\bar{X}_{n-1}$	$\bar{X}_{n-1}$	
			Calculated	Observed			Calculated	Observed
1960	18	30	3.6	4.1	5	4	1.1	1.2
1961	21	28	3.5	7.5	10	7	2.0	2.5
1962	22	28	7.1	7.9	14	14	3.0	2.9
1963	24	29	5.5	5.0	12	10	2.5	2.5
1964	29	26	4.3	4.3	8	9	1.5	2.4

Table 5. Calculated and observed strontium-90/calcium ratios in adult bone

Year	New York City			San Francisco		
	$\bar{X}_{n-1}$	$\bar{X}_n$		$\bar{X}_{n-1}$	$\bar{X}_n$	
		Calculated	Observed		Calculated	Observed
1961			0.89			0.53
1962	10.5	1.91	1.08	4.1	0.55	.74
1963	31.3	1.36	1.55	8.2	.93	.98
1964	34.4	2.06	2.08	14.8	1.16	1.23
1965	16.3	2.14	2.13	13.8	1.35	1.16
1966	23.0	2.35	2.06	9.1	1.23	1.35

values rather than values at the beginning of calendar years, the appropriate value of Z that should be used in the above equation is the average value for the interval from midyear to midyear. A comparison of calculated with observed strontium-90/calcium ratios in adult bone using this formula and the appropriate diet values, taken from a graph of the results of the tri-city diet studies, is shown in table 5.

Conclusions

Results of the bone sampling program during 1966 were consistent with expectations. It appears that reasonably accurate predictions can be made of bone strontium-90 concentrations from diet strontium-90 concentrations. The agreement between predictions and observations supports the view that the diet and bone sampling programs in the two cities are representative. Moreover, the proportionality in bone levels to diet concentrations suggests that bone concentrations may be inferred wherever reasonable estimates of diet strontium-90 intake can be made.

Constructing models to predict strontium-90 concentrations in bones of children from 1 to 19 years of age from survey diet and bone data is very difficult because of the few samples obtainable in any given year. It is hoped that the meager data available each year may somehow be combined and that a model may then be developed that is as good as that for infants and adults now in existence.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation stand-

ards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.¹

Summaries of the environmental radioactivity data follow for the Lawrence Radiation Laboratory and the Mound Laboratory.

¹ Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory July-December 1966²

*University of California
Berkeley, California*

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (figure 1). Winds are generally westerly; annual rainfall is 23 inches, most of which usually falls during the period from November through April. Technical facilities include a 6.3 BeV proton accelerator (Bevatron), a 700-MeV cyclotron, a 10-MeV linear accelerator, an 88-inch cyclotron, and associated chemistry and physics laboratories.

The environmental monitoring program includes sampling for radionuclides in the atmosphere, surface and ground waters, sewage, rain, and dry depositions.

Three types of atmospheric samples are taken: laboratory exhaust duct samples, local area samples and perimeter samples. One hundred and twelve exhaust air ducts with potential for releasing radioactive contaminants are sampled continuously at a flow rate of 2 liters/minute. The 1-inch diameter filters are changed weekly and counted for beta radioactivity by an end-window Geiger-Mueller tube and for

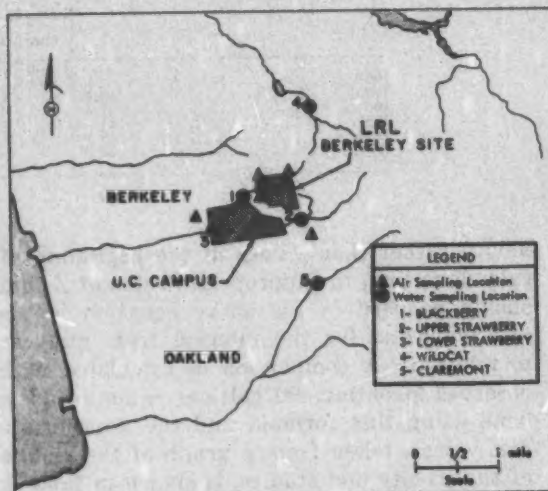


Figure 1. Environmental sampling locations at the Berkeley site

alpha radioactivity by a thin-window proportional counter. Continuous local area and perimeter air samples are taken at scattered locations on the laboratory site and at the property line, respectively. The samples are obtained on 4-by 9-inch HV-70 filter papers at 4 cubic feet per minute. The filters are collected weekly and counted for alpha radioactivity by a thin-window proportional counter and for beta radioactivity by a 30 mg/cm²-window Geiger-Mueller tube. The levels of radioactivity observed in each type of sample are presented in table 1.

² Summarized from "Results of Environmental Radioactivity Sampling Program, July-December 1966," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

**Table 1. Atmospheric monitoring, LRL Berkeley site
July-December 1966**

Sampling location (number of locations)	Number of samples	Concentration ^a (pCi/m ³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Exhaust ducts (112)	4,978	<0.07	(^c)	<1.6	(^c)
Local area (2)	224	<.006	<0.006	<.15	1.7
Perimeter (4)	104	<.006	0.006	<.15	2.3

^a Limits of detectability for individual samples (pCi/m³)
Exhaust ducts..... 0.07 alpha 1.6 beta
Local area and perimeter..... 0.006 alpha 0.15 beta
^b No reported data.

Rain and dry deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Precipitation samples are concentrated by evaporation. Dry samples are removed from the collection vessel with a dilute nitric acid rinse and then concentrated by evaporation. Final evaporation is effected in 2-inch diameter stainless-steel planchets, which are flamed and coated with a thin lacquer film. The planchets are counted for alpha radioactivity in an internal-flow proportional counter and for beta radioactivity with a thin-window, low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Deposition data are given in table 2.

**Table 2. Total deposition, LRL Berkeley site
July-December 1966**

Sampling location (number of locations)	Number of samples	Deposition (pCi/m ²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum ^a	Average	Maximum ^a
Local area (10)	22	0.08	0.19	4.22	5.00
Perimeter (4)	22	.12	.18	4.90	6.68

^a Maximum deposition at a single location for the 6-month period.

Water samples are taken from sewers, onsite streams, and offsite streams. Two sewer lines serve the LRL area. The "Hearst" sewer receives waste from the larger part of the area. A sampling system takes a continuous proportional sample from the Hearst sewer as it leaves the laboratory boundary. Samples are

also taken of waste feeding into the Hearst sewer from buildings 70, 70A, and 71. The "Strawberry" sewer receives waste from the southeast part of the laboratory site. A monitoring station takes a continuous proportional sample from this sewer. Continuous samples are also taken from the acid waste systems in building 74. The concentrations of radioactive wastes in sewage, shown in table 3, are either those observed directly in samples from the sewer line or those calculated from samples taken from contributing waste streams, whichever is the higher value. Strawberry and Blackberry Creeks comprise the laboratory's storm drainage. These are sampled weekly at three locations. Two other nearby offsite streams are also sampled weekly. All water samples are handled in the same manner as rain samples. The results from the water sampling program are presented in table 3.

**Table 3. Water monitoring, LRL Berkeley site
July-December 1966**

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Sewage:					
Hearst sewer.....	28	0.96	1.1	28	100
Strawberry sewer....	26	.68	3.6	89	283
Tap water.....	20	.00	.4	3.3	4.3
Surface water:					
Onsite streams.....	51	1.02	12.3	7.4	98.3
Offsite streams.....	53	.71	10.0	3.6	9.3

Livermore site

The Livermore site of LRL (figure 2) is located about 50 miles southeast of San Francisco, Calif. Annual precipitation in the Livermore Valley is about 14 inches; prevailing winds are from the west with frequent nocturnal inversions. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in

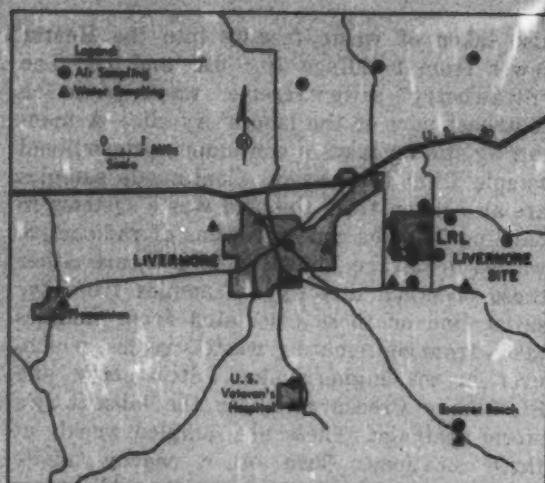


Figure 2. Environmental sampling locations at the Livermore site

the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from two dairies in the Livermore Valley and one in another valley about 25 miles away, which is used as a check. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV-70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas-flow proportional detectors for both alpha and beta radioactivity measurements. Alpha radioactivity in 412 air samples collected from 15 sampling locations averaged 0.0010 pCi/m^3 , while

beta radioactivity averaged 0.051 pCi/m^3 . The applicable AEC radiation protection standards are 0.040 pCi/m^3 for alpha-particle emitters and 1 pCi/m^3 for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with fluoroglass dosimeters located at nine points on the site perimeter and at two nearby ranches. Due to equipment failure, the data for the second half of 1966 are not available at this time.

Domestic water samples are collected monthly from nine nearby sources. No water sample showed alpha radioactivity above the limit of sensitivity (5.0 pCi/liter) for the automatic gas-flow proportional detection system. The beta radioactivity ranged from less than the limit of sensitivity (1.8 pCi/liter) to 11 pCi/liter . The average alpha and beta radioactivity in water samples was less than their respective AEC radiation protection standards of 10 and 100 pCi/liter .

Samples are collected every Monday, Wednesday, and Friday, at the sewer line leaving the southwest project boundary, where it connects with the Livermore domestic sewerage system. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that the liquid effluent from the laboratory is not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner). Radioactivity levels in the raw sewage, oxidation ponds, and dried sludge are summarized in table 4.

Table 4. Environmental sampling, LRL Livermore site July-December 1966

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Raw sewage (pCi/liter).....	9	43
Oxidation ponds (pCi/liter).....	8	28
Dried sludge (pCi/g).....	17	30

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity fluctuated from less than the limit of sensitivity (1.5 pCi/g) to 9 pCi/g . The beta radioactivity fluctuated from less than the limit of sensitivity

(2.5 pCi/g) to a single sample high of 128 pCi/g following the third Chinese nuclear test in May. All samples were below 85 pCi/g. The average alpha radioactivity was 3.0 pCi/g and the average beta radioactivity was 14.2 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 4 pCi/liter of cesium-137 and 2 pCi/liter of cerium-141-144, for the two Livermore dairies. These levels closely correspond to those for a dairy in a neighboring valley about 25 miles from Livermore.

Site 300

Site 300 (figure 3) is located in a very sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Samples are collected from streams only during the winter months when water flow exists. Soil samples are collected quarterly at nine offsite locations. Only top

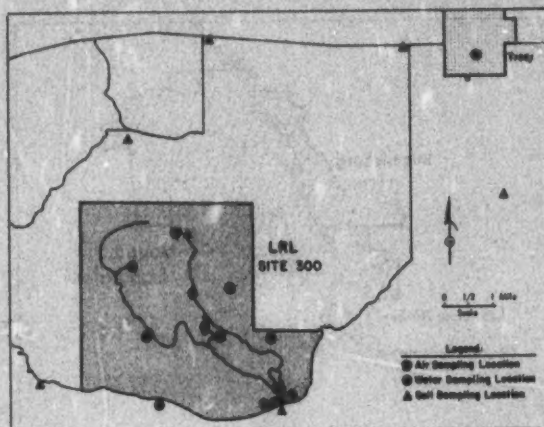


Figure 3. Sampling locations at Site 300 Lawrence Radiation Laboratory

layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the laboratory in Livermore. The average radioactivity levels in samples collected are summarized in table 5.

Table 5. Environmental sampling, LRL Site 300 July-December 1966

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Air (pCi/m ³).....	0.0008	0.055
Water (pCi/liter).....	<5	4.3
Soil (pCi/g).....	6	11

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-December 1965	November 1966
January-June 1966	June 1967

2. Mound Laboratory, July-December 1966 and annual summary 1966²

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory

is specific for the radionuclides which could be released to the environment. Only polonium-210, plutonium-239, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of

² Summarized from "Environmental Monitoring Report: July-December 1966 and 1966 summary," MLM-1391.

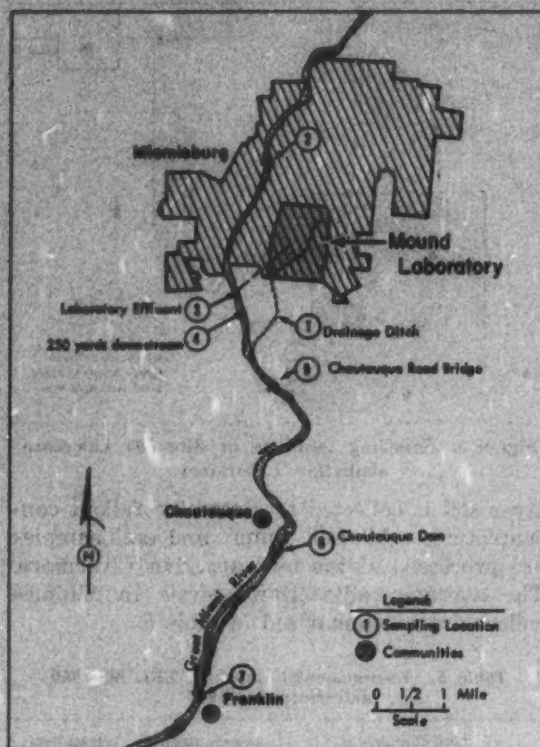


Figure 4. Water sampling locations, Mound Laboratory

tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air in a network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

During the 6-month period ending December 1966, weekly samples were collected and analyzed for airborne tritium. In all cases, tritium was not detectable in offsite environmental air samples.

A total of 366 air samples were collected and analyzed for possible polonium and plutonium contaminants in the environment. A long-lived gross alpha radioactivity determination was made on filter-paper samples after a sufficient time had elapsed to permit the decay of the short-lived daughter products of radon and thoron. The filter-paper samples were counted for alpha-particle emissions in a low-back-

ground proportional counter. The average measured concentrations of alpha radioactivity in air are summarized in table 6. No specific determinations of polonium-210 or plutonium-239 were made, since the gross alpha radioactivity remained substantially below the environmental limits for these nuclides.

Table 6. Atmospheric monitoring of long-lived alpha radioactivity, Mound Laboratory environs, July-December 1966

Sampling location	Number of samples	Concentration ($\mu\text{Ci}/\text{m}^3$)	
		Maximum ^a	Average ^b
Upwind from laboratory.....	53	0.0168	0.0041
Downwind from laboratory.....	514	.5543	.0724

^a The minimum detectable concentration for long-lived alpha radioactivity concentrations in air is $0.0085 \mu\text{Ci}/\text{m}^3$. All values which were not detectable were set equal to this value when average values were calculated.

^b The applicable AEC radiation protection standards for uncontrolled areas are as follows:

Polonium-210 in air: $20 \mu\text{Ci}/\text{m}^3$
Plutonium-239 in air: $0.06 \mu\text{Ci}/\text{m}^3$

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of tritium. Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 4. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 4) is the point of discharge of the liquid polonium waste to the Great Miami River, and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

All of the river samples are analyzed for polonium-210. The drainage ditch samples and

Table 7. Ohio water monitoring for radioactivity, Mound Laboratory environs, July-December 1966

Nucleide and sampling location ^a	Number of samples	Concentration (pCi/liter)	
		Maximum	Average ^b
Polonium-210 ^c			
1 (Upstream from laboratory).....	34	2.7	1.8
2 (Laboratory effluent).....	34	1,792.8	121.2
3 (200-yards downstream).....	34	2.6	1.9
4 (Chautauque Road Bridge).....	34	2.7	1.9
5 (Chautauque Dam).....	34	1.8	1.5
6 (Franklin, Ohio).....	34	2.6	1.3
7 (Trenton, Ohio).....	34	1.8	1.0
8 (New Miami, Ohio).....	34	1.8	1.0
9 (7 miles upstream from New Baltimore, Ohio).....	34	1.8	1.0
10 (New Baltimore, Ohio).....	34	1.8	1.0
11 (Elizabethtown, Ohio).....	34	1.8	1.0
Hydrogen-3 (tritium) ^d			
1 (Drainage ditch).....	34	0.48 x 10 ⁶	0.10 x 10 ⁶
2 (Upstream from laboratory).....	34	.11 x 10 ⁶	.08 x 10 ⁶
3 (Laboratory effluent).....	34	.68 x 10 ⁶	.14 x 10 ⁶
4 (Chautauque Road Bridge).....	34	.14 x 10 ⁶	.08 x 10 ⁶
Plutonium-239 ^e			
1 (Drainage ditch).....	23	14.3 x 10 ³	1.1 x 10 ³

- ^a See Figure 4 for number of sampling locations.
^b The applicable AEC radiation protection standards for uncontrolled area are as follows:
 Polonium-210 in water: 7×10^4 pCi/liter
 Plutonium-239 in water: 6×10^4 pCi/liter
 Hydrogen-3 in water: 3×10^6 pCi/liter
^c Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
^d Minimum detectable level for hydrogen-3 in water is 0.06×10^6 pCi/liter.
^e Minimum detectable level for plutonium-239 in water is 0.09 pCi/liter.

some of the river samples are analyzed for tritium. The drainage ditch samples are also analyzed for plutonium-239. Average concentrations of tritium, polonium-210, and plutonium-239 are given in table 7 for July-December 1966.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July-December 1966	November 1966
January-June 1966	May 1967

Reported Nuclear Detonation, October 1967

The U. S. Atomic Energy Commission announced two underground nuclear tests conducted at its Nevada Test Site during October 1967. On October 18, 1967 a nuclear test of intermediate yield (200 kilotons to 1 megaton TNT equivalent) was conducted underground. On October 25, an underground test of low yield (less than 20 kilotons TNT equivalent) was conducted at the Nevada Test Site.

On October 17, 1967, the Atomic Energy Commission announced that the United States had recorded seismic signals which originated from the Soviet nuclear test area in the Semi-

palatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20 to 200 kilotons TNT equivalent).

On October 23, 1967, the AEC announced that the United States had recorded seismic signals which originated from the Soviet nuclear test area in the Novaya Zemlya region. The signals were equivalent to those of a nuclear test in the lower end of the intermediate range (200 kilotons to 1 megaton TNT equivalent).

SYNOPSIS

Synopsis of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

STATE HEALTH DEPARTMENT SAMPLING CRITERIA FOR SURVEILLANCE OF RADIOACTIVITY IN MILK. E. H. Neill and D. E. Sorely. *Radiological Health Data and Reports*, Vol. 8, November 1967, pp. 621-627.

This report summarizes criteria used by the States in setting up their milk sampling programs for measurement of radioactivity and the sample typing, collection points, and measurements used. Also included are the times required by the States from sample collection to the final radioactivity concentrations of the various radioisotopes found in milk.

KEY WORDS: Cesium-137, geography, iodine-131, milk surveillance, nuclear facilities, pasteurized milk, population, production and processing, raw milk, State Health departments, strontium-89, strontium-90.

Erratum

In the September 1967 issue of *Radiological Health Data and Reports*, the footnote to the report "Radioactivity in the Mexican Environment," on page 495, should have read as follows:

"Mr. Vasquez Barete is Director General of Radiological Safety and Mrs. Nulman is physicist, Comision Nacional de Energia Nuclear, Mexico, D.F."

The editors regret the error.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 12, December 1967

In August 1958, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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X-ray Patterns and Intensities From High Voltage Shunt Regulator Tubes for Color Television Receivers

H. F. Stewart, N. F. Modine, E. G. Murphy and J. W. Rolofson¹

Recent X-ray emission from some color television receivers greater than the NCRP recommended maximum came to the attention of the Public Health Service. The radiation came from a high voltage shunt regulator tube. This discovery prompted a general investigation by the Public Health Service of radiation emission from regulator tubes used in color television receivers. This report describes the construction of high voltage shunt regulator tubes, laboratory test methods, and the measured X-ray distributions in direction, quality, and intensity from 227 shunt regulator tubes.

The X rays generated within television tubes and other high voltage, high vacuum devices, have long been recognized as potential causes of radiation exposure (1-5). In 1960, the National Committee on Radiation Protection and Measurements (NCRP) published the following recommendation with regard to the maximum permissible dose from television receivers:

"... from a genetic point of view even sources of minute radiation are of significance if they affect a large number of people. X rays emitted by home television sets are, therefore, of interest because of the high percentage of the population involved. In order to insure that the television contribution to the population gonad dose will be only a small fraction of that due to natural background radiation, the NCRP recommends that the exposure dose rate at any readily accessible point 5 cm from the surface of any home television receiver shall not exceed 0.5 mR per hour under normal operating conditions" (6).

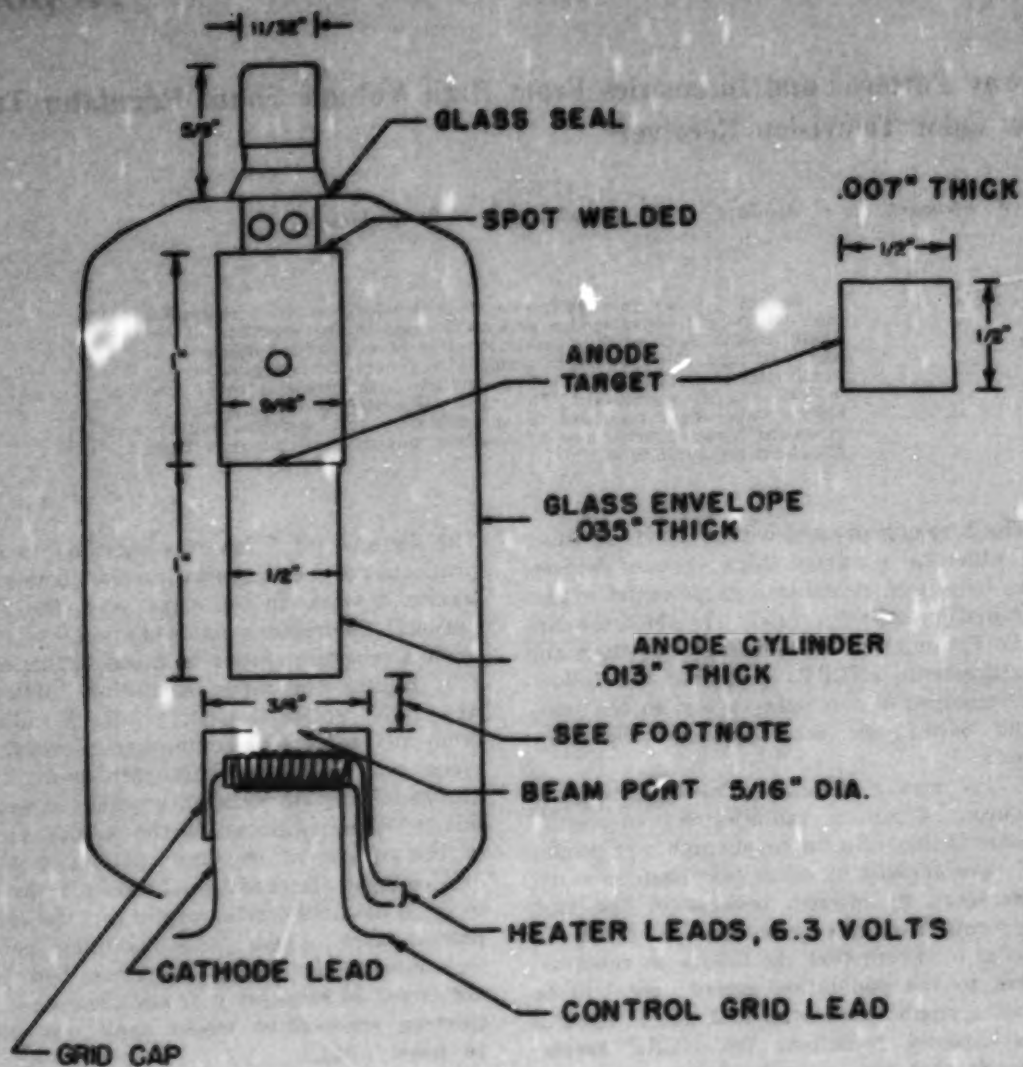
The distance of 5 cm was specified to make practical the use of ionization chambers as detection devices. In the same year, the International Commission on Radiation Protection made a recommendation identical to that above (7). British Standards Institution Publication 415 of 1957 states, in part, "... the X radiation from any equipment containing electronic devices, such as high voltage cathode-ray tubes and rectifying valves, shall nowhere exceed 0.5 mR/hr when measured on the outside surface of the equipment housing" (8). The NCRP also changed its recommendation for the dose to the skin of the whole body in this low energy photon range to read, "The maximum permissible dose to the skin of the whole body shall not exceed 30 rems per year and the dose in any thirteen consecutive weeks shall not exceed 10 rems." (6).

Description of high voltage shunt regulator tubes

In black and white television receivers the regulation of the high voltage for the picture tube is not necessary for satisfactory operation. Color picture tubes, on the other hand, require precise voltage regulation to insure proper focusing of their three electron beams on the three small bits of red, green, and blue phosphor within each image element on the

¹ Dr. Stewart is director, X-Ray Exposure Control Laboratory (XECL); Mr. Modine is acting chief, Dosimetry and Calibration Unit, XECL; Mr. Murphy is chief, Technical Services Unit, XECL; and Mr. Rolofson is assistant chief, Dosimetry and Calibration Unit, XECL, National Center for Radiological Health.

SHUNT REGULATOR TUBE CONSTRUCTION (6EF4 — 6LC6)



NOTE: DISTANCE BETWEEN ANODE & GRID CAP
VARIES RCA 6EF4 $\sim 3/16"$ AND GE 6LC6 $\sim 1/4"$

Figure 1. Construction of RCA labeled 6EF4 and GE labeled 6LC6 shunt regulator tubes

screen. Many color receivers achieve this regulation by means of a high voltage shunt regulator tube in the high voltage supply, while other receivers utilize circuit designs which regulate the high voltage without the use of a shunt regulator tube. Table 1 identifies and describes some of the shunt voltage regulator tube types commonly used in color television receivers. These tubes are all quite similar electronically but differ in the number of base pins, internal connections, and internal mechanical configuration. Figure 1 is a sketch of the 6EP4 and 6LC6 types. Shunt regulator tubes in table 1 are low-current, high voltage, beam triodes. A regulator tube maintains a constant accelerating voltage on the picture tube under varying currents which then produce the image brightness and color changes. The control circuit for the shunt regulator tube makes it take that portion of the constant total current from the power supply which is not being used by the picture tube. When the picture is bright, little current goes through the shunt regulator tube; a dim scene shunts more of the current through the shunt regulator tube, which must always sustain the full accelerating potential. Therefore, X rays of varying intensity, but constant accelerating potential, are produced at the target, a molybdenum plate in the anode of the shunt regulator tube and are emitted in all directions when a color television set is operating. The X rays emitted laterally are attenuated by the anode cylinder, generally composed of iron, and by the glass envelope.

The grid cap shown in figure 1 is just large enough to intercept all the X rays directed

downward. However, a small lateral misalignment of the grid cap with the anode cylinder or a small angular tilt of the latter could allow X rays from the target area of the anode to pass downward alongside the grid cap and out through the glass envelope. Such an escape of X rays was detected in many of the tests reported here. X rays were projected downward through the base of the tube in the form of a crescent-shaped cross sectional area. The angle from vertical of this downward projection ranged from 18 to 29 degrees.

Recently, shunt regulator tubes have been developed and are being used to replace those found to emit excessive radiation levels. These new tubes are designed to limit the amount of X-ray leakage to a maximum of 0.5 mR/hour, such as that stated in the GE Product Information sheet for the 6LH6 tube: "X-radiation is measured at a distance of four inches from the tube with a potential of 25 kilovolts applied to the anode and a current of 0.5 milliamperes flowing to the anode. These measurements should be made with an ion chamber rate meter which has been properly calibrated or corrected for accurate response in this energy range and which has a window diameter of at least 3 1/4 inches."

The reduction in radiation leakage was achieved by making the following four structural changes:

1. The diameter of the grid cap was increased so that alignment of the anode cylinder with the cap was less critical.
2. The bottom edge of the anode cylinder was rolled inward to form a lip.

Table 1. Shunt regulator tubes for color television receivers

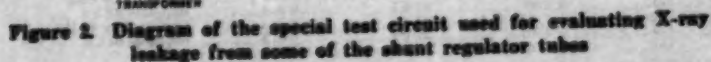
Tube type	Brand name	Actual mcr.	Date of initial production	Design maximum plate voltage	Design maximum plate current	Notes
6BD4	RCA	RCA	12/58	30 kV	1.5 mA	Supersedes 6BD4. Tube designed by RCA, but manufactured by Sylvania.
6BD4A	RCA	RCA	3/54	27 kV	1.5 mA	
6BE4	SYL	See note	Before '53	27 kV	1.5 mA	
6BE4	RCA	RCA	10/54	27 kV	1.5 mA	Rolled lip on bottom of anode cylinder similar to 6BE4A; interchangeable with 6BE4 & 6BE4A.
6BE4A	RCA	GE	4/55	27 kV	1.5 mA	
6BE4B	RCA	RCA	3/55	27 kV	1.5 mA	
6EA4	GE	GE	8/54	27 kV	1.5 mA	Replaced by 6BE4.
6EA4A	GE	GE	4/57	27 kV	1.5 mA	Replaces 6EA4 rolled lip on bottom of anode cylinder.
6EP4	GE	GE	8/55	27 kV	1.5 mA	Replaced by 6EP4.
6EP4A	GE	GE	4/57	27 kV	1.5 mA	Replaces 6EP4.
6LC6	GE	GE	1/57	27 kV	1.5 mA	Replaced by 6LH6.
6LH6	GE	GE	4/57	27 kV	1.5 mA	Replaces 6LC6.
6LH6A	GE	GE	4/57	27 kV	1.5 mA	

- ### Test methods and equipment

only 25 microamperes at 25 kilovolts and therefore did not significantly lower the high voltage from a television receiver power supply giving more than 850 microamperes.

One special shunt regulator tube test set was built to provide a means of testing some of the tubes under more precise control of voltage and current. It was composed of a wooden table with a set of tube sockets on pedestals wired to special power supplies for low and high voltage. Figure 2 is a simplified schematic of the circuit. A high voltage constant potential power supply (Sorenson Model 9030-5) provided the anode voltage with a maximum ripple of 1.5 percent at 5 milliamperes. The output voltage of this power supply was controlled by varying its input voltage with a Variac. The Variac, in turn, was powered from a General Radio type 1570 line voltage regulator to insure minimum changes in anode voltage throughout a given test. The current through the anode of the tube was controlled both by filament current and by grid bias. A Variac was used to set the current of the filament transformer, thus, controlling the temperature of the cathode. A variable regulated d.c. power supply was included in the cathode circuit to provide grid bias. The high voltage was ordinarily mon-

SHORT REGULATOR TIME TEST CIRCUIT



itored with a microammeter in series with a 300 megohm resistor. At 30 kilovolts, 0.1 milliampere was drawn by the 300 megohm resistor. A precision electronic potentiometer connected to a bank of high voltage resistors, whose values had previously been accurately measured, and drawing 0.16 milliamperes at 30 kilovolts provided a calibration of this voltmeter.

The radiation patterns and intensities were measured with three types of detectors, ion-chamber rate meters, Geiger-Mueller count-rate meters with window probes and X-ray film in paper packages. Each detector was calibrated against the response of the free air, ion chamber for soft X rays of the quality range (25 to 30 kilovolts and 0.15 to 0.3 mm aluminum half-value layers) produced by the shunt regulator tubes and under television operating conditions. The portable ionization chamber rate meter and the free air ionization chamber were alternately aligned in a broad X-ray beam uniform to better than 0.5 percent over the 3½-inch diameter of the portable window. A similar substitution method was used to calibrate the X-ray film, held behind a rotating lead sector wheel with an acceptance window ¾ inch wide by 4 inches high. The Geiger-Mueller rate meter was intercompared with the portable ionization chamber rate meter in the broad beam from a superficial therapy X-ray machine suitably filtered. The calibration factors for each type of detector varied less than 10 percent from the average over the X-ray quality range of interest.

The calibrations enabled conversion of scale readings to accurate exposure rates in an X-ray beam broad enough to cover the entire aperture of the radiation detectors with a uniform intensity. Geometric corrections for partial irradiation of the ion chamber rate meter and the G-M count-rate meters were obviously not obtainable *a priori* by calibration because the crescent-shaped X-ray beams covered fractions of even the G-M window varying from ¾ to less than 1/100, as shown by comparison with corresponding film measurements in the free air ion chamber. Film density readings provided the only accurate exposure rate measurements of the narrow downward X-ray beams. The other two types of detector were relied on for routine exposure measurements when initial

film tests had determined that the X-ray beams were nearly uniform, *e.g.*, laterally and upward.

Measurements were made at significant points around more than 300 shunt voltage regulator tubes. These included samples of a dozen or more of each of eight types of shunt regulator tubes (6LC6, 6LH6, 6EF4, 6EA4, 6EJ4, 6EH4, 6BK4A, and 6BK4B) purchased from local electronics supply houses in the Washington, D.C. area during May 1967. The open market samples totaled 127 shunt regulator tubes. Two hundred additional tubes (100 6EF4's and 100 6LC6's) were supplied by the General Electric Company.

The radiation measurements were made at the following locations around the regulator tube:

1. The point in a plane 11 inches below the target area of the anode of the tube at which a Geiger probe, with window pointed toward the target area, gave the maximum reading. In case of misaligned electrodes, this point approximately located the downward crescent-shaped beam of X rays coming directly from the anode.
2. The point in a plane 8 inches below the anode target at which the horizontally placed window of an ion chamber rate-meter gave the maximum reading. This process also located and monitored the downward beam.
3. Four points in a horizontal plane through the anode target, equally spaced around a circle with a radius of 12 inches, from which a Geiger probe was aimed toward the anode target. These measurements accurately sampled the lateral X-ray exposure rate.
4. A horizontal area 7 inches below the anode target on which a radiographic film packet was placed. In some cases a distance of 7 inches below the base was used. The film completely recorded and accurately measured the pattern of X rays emitted in the downward direction.
5. A paper-packaged 14- by 17-inch film placed on the inner surface of a cylinder 14 inches long and 5.5 inches in diameter was centered around the tube. This recorded most of the lateral X-ray leakage.

Exposure rates could be estimated at the film's average radial distance of $2\frac{1}{4}$ inches from the axis.

6. The axial point 12 inches above the anode target at which a Geiger probe window was placed. The upward exposure rate was measured at this point.

Not all these points were measured for all the tubes since techniques were modified during the testing.

Patterns of X-ray emission from high voltage shunt regulator tubes

Figure 3 illustrates autoradiographs of six of the first ten purchased 6EF4 tubes showing varying degrees of misalignment. A Kodak Royal Blue Ready Pack was exposed $9\frac{1}{2}$ inches below each regulator tube anode target operated for 1 hour. The receiver normally gave the regulator tube a high voltage of 25 kilovolts measured from anode to ground and a current

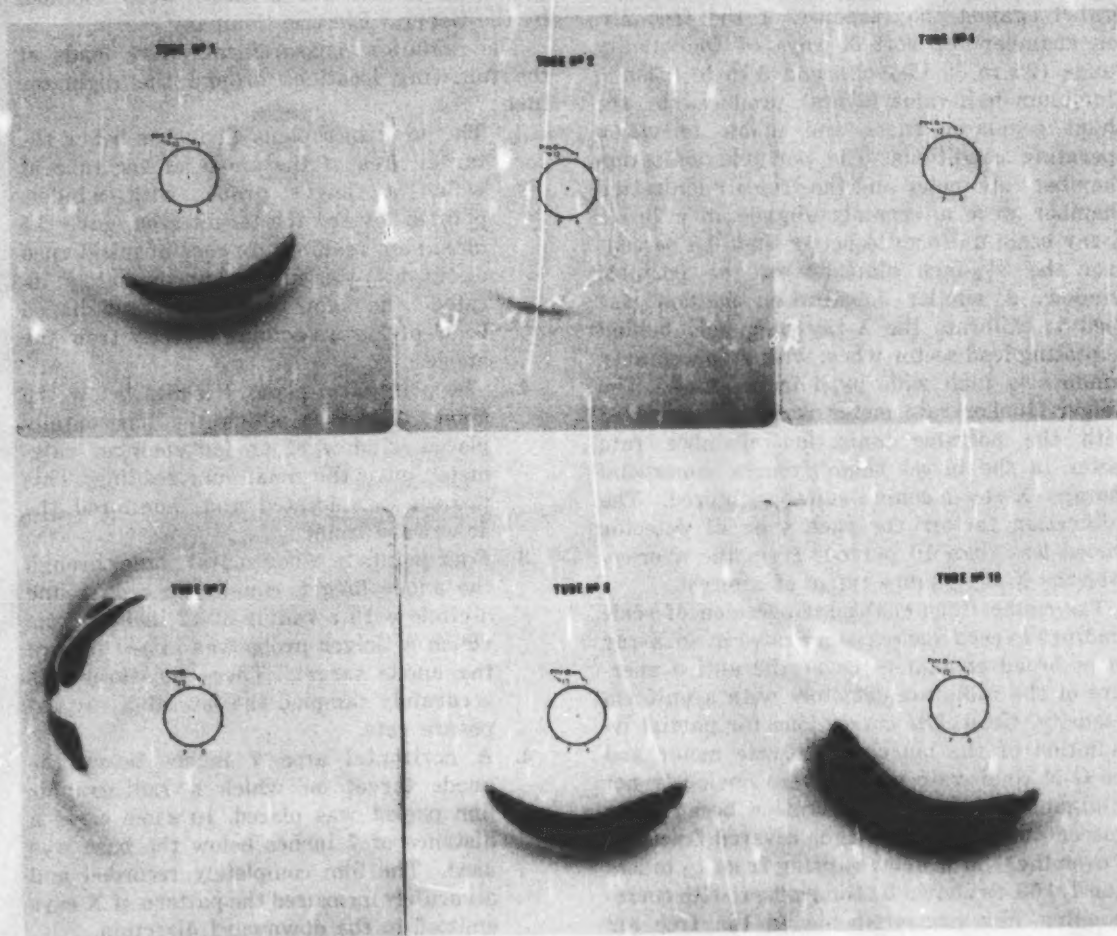


Figure 3. Variation in images of X-ray leakage from misaligned 6EF4 tubes (The 8- by 10-inch film packs were placed in a plane perpendicular to the axis of the tube and 7 inches below the tube base. The circles represent the projection of the tube and pin positions on the radiograph.)

averaging 0.85 milliamperes. Width, angle, and exposure rate measurements of the X-ray leakage patterns from these tubes are included in table 2, which summarizes our data on the first ten 6EF4 tubes purchased for test.

Table 2. Spatial distribution and exposure rate of X-ray leakage detected on photographic film placed below eight shunt regulator tubes of type 6EF4 purchased in the District of Columbia early in May 1967

Tube serial number ^a	Maximum image width ^b	Maximum exposure rate ^b (mR/hr)
1	1 1/4	3000
2	1 1/4	60
3	no image	low
4	1 1/4	45
5	1 1/4	1700
6	1 1/4	4000
7	1 1/4	low
8	no image	low
9	1	8000
10		

^a Tubes 5 and 6 were inoperable when tested.

^b Image was 7 inches below tube base or 9 1/4 inches below X-ray target.

Similar autoradiographs produced by 6LC6 tubes and their 6LH6 replacement tubes, randomly selected from batches of 115 and 10, are shown in the left and right images of figure 4, respectively. The top images resulted from 14- by 17-inch Royal Blue films in Ready Pack looped around the tubes (location 5) and the central images, from like films 7 inches below the tube anode targets (location 4), as suggested by the bottom photograph. The tubes were powered by the special circuit of figure 2 at 27 kilovolts and one milliamperes for times sufficient to produce good images. One sees that there is no downward beam of X rays from the new type of tube; the lateral band of X rays is much reduced in quantity and more uniformly distributed. The quantitative differences are discussed later in this report. Similar radiation patterns were observed for the other shunt regulator tubes.

Quality of X rays from shunt regulator tubes

To illustrate the quality of the X rays, an aluminum attenuation curve for the X-ray beam downward from a 6LC6 tube is plotted in figure 5. These measurements were made using a Nuclear Chicago model 2588 survey meter, with a thin-end window model 2526 medium range ionization chamber. This ionization

chamber was correct within 10 percent for a broad beam of X rays in the energy region being investigated. Figure 5 shows the half-value layer of the beam to be 0.33 mm of aluminum, which corresponds to an effective energy of 16 keV (9). Hayashi *et al.* obtained similar values from 6BK4 tubes (10).

Downward X-ray intensities from shunt regulator tubes

Figures 6 and 7 display the readings of a calibrated G-M probe underneath 96 6EF4 tubes and 90 6LC6 tubes, respectively, as cumulated percent frequency curves on logarithmic probability grids. The number of regulator tubes with maximum nominal readings greater than the indicated ordinate, in milliroentgens per hour (mR/hr), as determined by a G-M survey instrument calibrated in an equivalent X-ray field in the same manner used in the X-ray survey, are plotted as percents of the total number of tubes tested. These readings were generally lower than the exposure rates measured by film and were used only to intercompare tubes producing the lower exposure rates.

Figure 8 presents the higher exposure rates recorded on calibrated films placed in a horizontal plane 7 inches under the anode targets of 62 of the 6EF4 tubes. The film was calibrated for X rays of the same quality as those emitted downward from the regulator tubes. When a film was excessively dark, another film was exposed for a shorter time and thus an accurate rate for this severely misaligned tube was calculated.

The eight 6EF4 tubes showing the greatest X-ray leakage represented 12 percent of these tubes and emitted downward beams measuring more than 5,000 mR/hr at the film position. Two 6EF4 tubes, or about 2 percent of the tubes tested gave more than 50,000 mR/hr, one tube showing a leakage of 170,000 mR/hr. G-M probe results are shown in figure 9 for some 6EA4 and 6EF4 tubes that were purchased locally. The small 6EF4 sample included about the same percentages of tubes with G-M

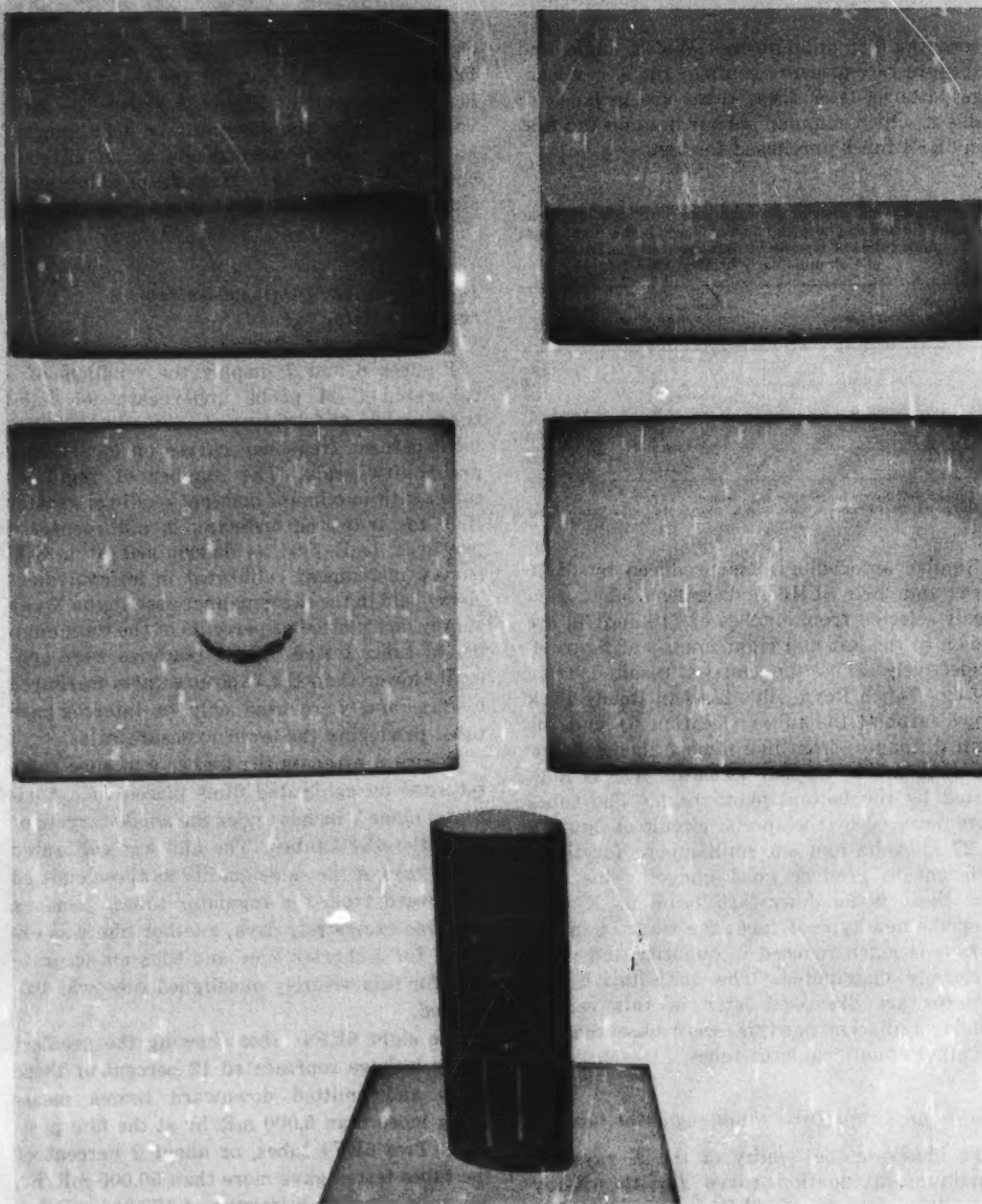


Figure 4. Photograph of radiographic films exposed using shunt regulator tubes
 (The two films at the left were exposed using 6LC6 tube #212 operated for 95 minutes
 while the two films on the right resulted from a 39-hour exposure to 6LH6 tube #5.
 The spatial relationships of tube, wrapped film and flat film are shown in the com-
 posite photograph at bottom of figure.)

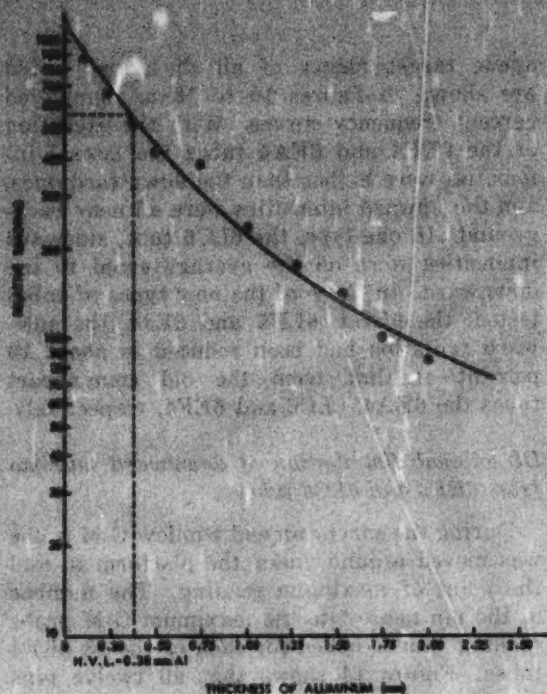


Figure 5. Aluminum attenuation curve of X-rays emitted from a 6LC6 shunt regulator tube operating at 25 kV

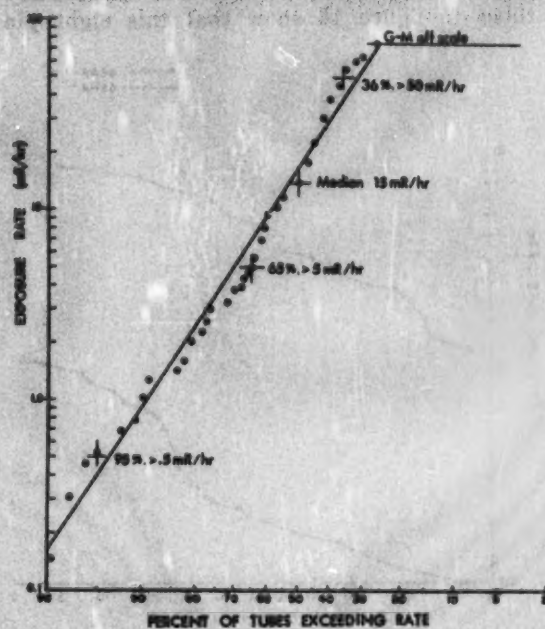


Figure 6. Distribution of maximum RM-3A Geiger-Mueller exposure rate 11 inches under anode targets of 96 6EF4 tubes supplied by GE

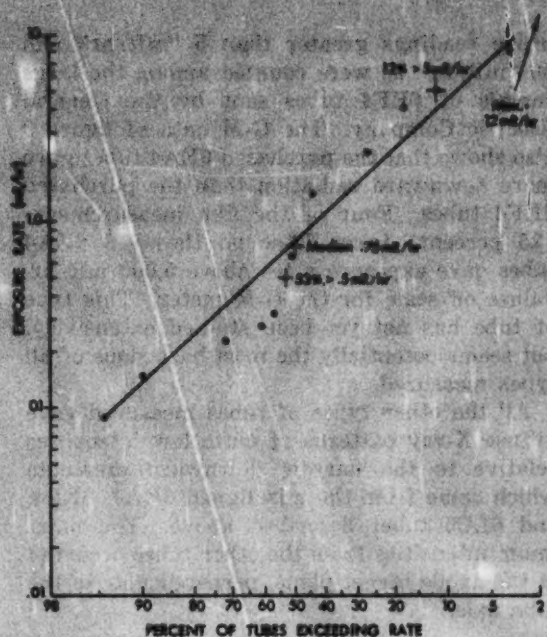


Figure 7. Distribution of maximum ES66-B Geiger-Mueller exposure rates 11 inches under anode targets of 90 6LC6 tubes supplied by GE

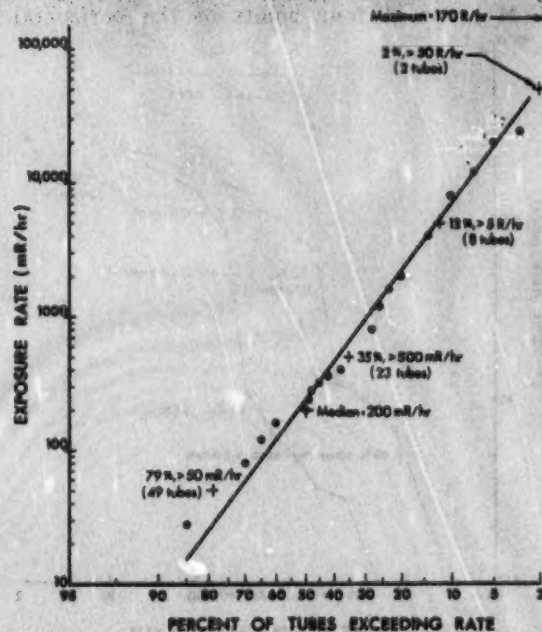


Figure 8. Distribution of maximum film exposure readings 7 inches under anode targets of 62 6EF4 tubes supplied by GE

probe readings greater than 5 "mR/hr" and 50 "mR/hr" as were counted among the large sample of 6EF4 tubes sent by the General Electric Company. The G-M data of figure 9 also shows that the purchased 6EA4 tubes gave more downward radiation than the purchased 6EF4 tubes. Four of the film measurements (25 percent) taken later on these 16 6EA4 tubes gave exposure rates above 5,000 mR/hr, values off-scale for the G-M meter. This type of tube has not yet been studied extensively, but seems potentially the most hazardous of all types measured.

All the other types of tubes measured gave diffuse X-ray patterns of quite low intensities relative to the narrow downward crescents which came from the misaligned 6EA4, 6EF4, and 6LC6 tubes described above. The maximum intensities from the other tubes occurred in the anode target plane, perpendicular to the tube axis.

Intensities in other directions from shunt regulator tubes

The readings taken with an end window G-M probe at four points of the horizontal

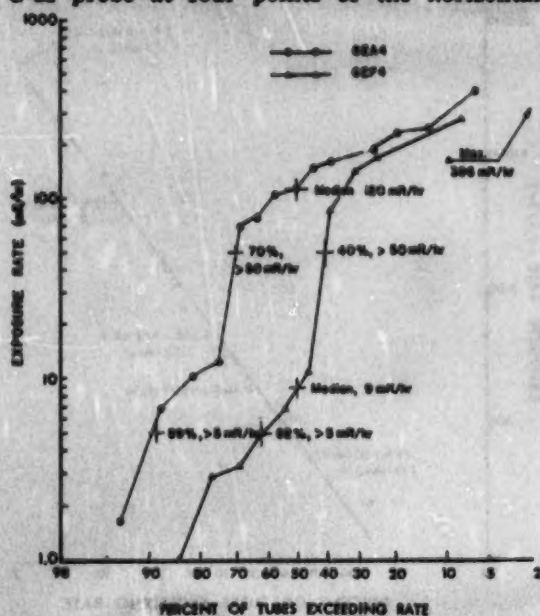


Figure 9. Distribution of maximum E500-B Geiger-Mueller exposure rates 11 inches under anode targets of 16 6EA4 and 13 6EF4 tubes purchased locally

anode target planes of all the tubes tested are shown in figures 10 to 18 as cumulated percent frequency curves. With the exception of the 6EF4 and 6EA4 tubes the lateral intensities were higher than the downward ones, and the upward intensities were all near background. In one type, the 6LC6 tube, sideward intensities were on the average equal to the downward. In three of the new types of tubes tested, the 6EH4, 6LH6 and 6EJ4, the sideward radiation had been reduced to about 10 percent of that from the old counterpart tubes the 6EA4, 6LC6 and 6EF4, respectively.

Directional distribution of downward maxima from 6EF4 and 6LC6 tubes

During the survey an end window G-M probe was moved around under the platform to find the point of maximum reading. The number of the pin nearest to the maximum G-M probe reading was recorded for each of the 98 6EF4 tubes. Figure 14 shows that all twelve pins scored maxima two or more times and the largest score was 19 for pin 4.

Similar results of pin scores from 63 6LC6 tubes in figure 16 show that this eight pin

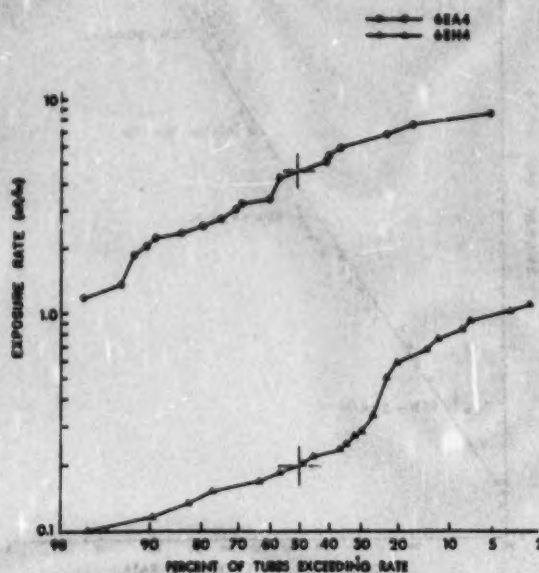


Figure 10. Distribution of E500-B Geiger-Mueller exposure rates 12 inches laterally from anode targets of 16 6EA4 tubes and 22 6EH4 replacement tubes

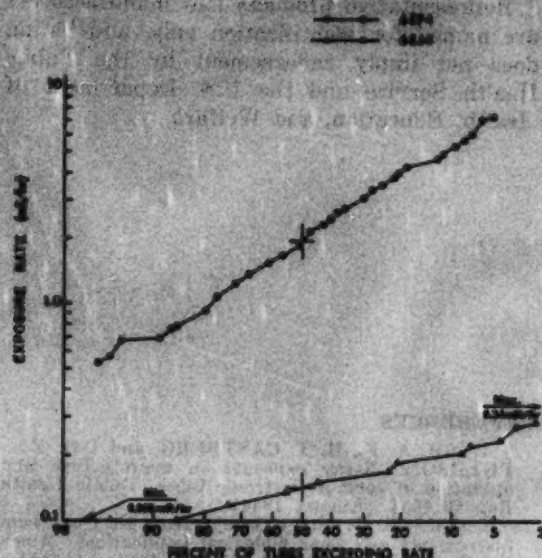


Figure 11. Distribution of E500-B Geiger-Mueller exposure rates 12 inches laterally from anode targets of 100 6EF4 tubes and 23 6EJ4 replacement tubes

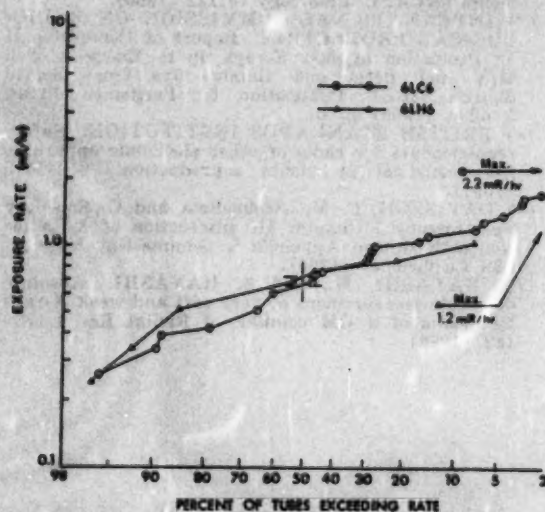


Figure 12. Distribution of E500-B Geiger-Mueller exposure rates 12 inches laterally from anode targets of 100 6LC6 tubes and 22 6LH6 replacement tubes

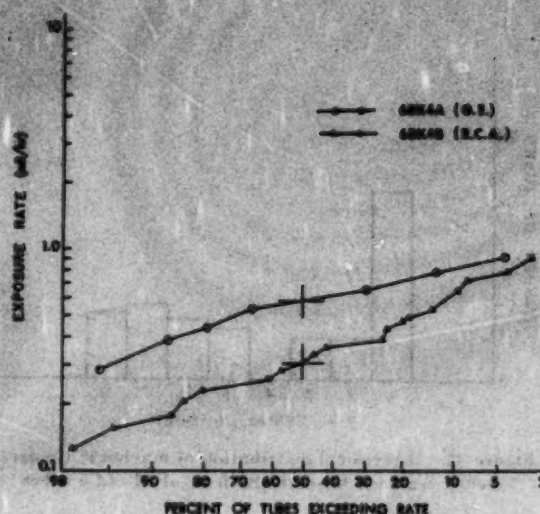


Figure 13. Distribution of E500-B Geiger-Mueller exposure rates 12 inches laterally from anode targets of 6 6BK4A tubes and 13 6BK4B replacement tubes

tube has an equal likelihood of giving a downward maximum in any pin direction except in the direction of pin 1, which appeared about twice as likely to mark the maximum. This random distribution of maximum directions is expected from the mechanical conditions of manufacture, a glassblowing operation.

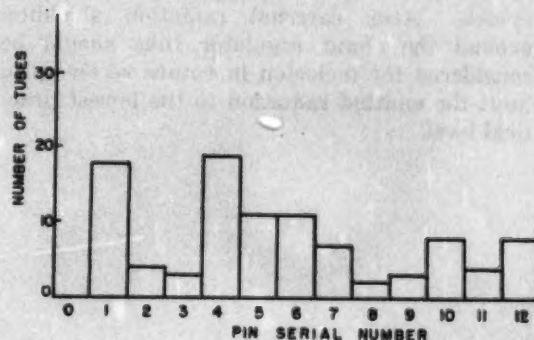


Figure 14. Directional distribution of maximum Geiger-Mueller readings beneath the base of 98 6EF4 tubes

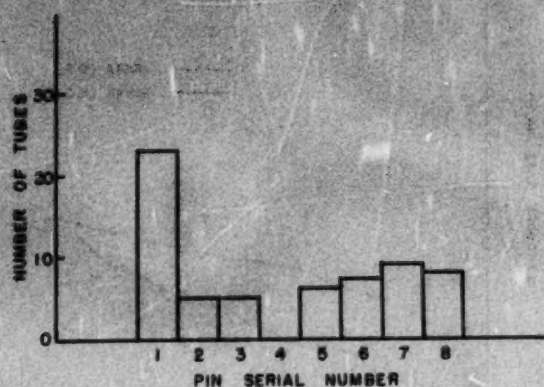


Figure 15. Directional distribution of maximum Geiger-Mueller readings beneath the base of 63 6LC6 tubes

Conclusions

Measured X-ray exposure was highest from those high voltage shunt regulator tubes whose anode structures were not properly aligned with the focusing grid cap, and which had the thinnest glass-tube walls. The amount of X-ray leakage was greatest from those tubes in which the misalignment was apparent visually. Thus, X-ray leakage is likely from any misaligned tube. Use of misaligned tubes as replacements in existing television receivers or as components of newly-produced receivers should be prevented. The more recently manufactured and modified shunt regulator tubes are preferred in all cases in lieu of the misaligned models. Also, external radiation shielding around the shunt regulator tube should be considered for inclusion in future receivers to limit the emitted radiation to the lowest practical level.

Representative products and manufacturers are named for identification only, and listing does not imply endorsement by the Public Health Service and the U.S. Department of Health, Education, and Welfare.

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Measurements of X-ray Exposure From a Home Color Television Receiver

H. J. L. Rechen, T. R. Lee, R. H. Schneider and O. G. Briscoe¹

A detailed examination of X-ray leakage has been made for two prototypes of the KC chassis manufactured by General Electric Company for home color television receivers. Typical operating conditions relevant to X-ray production from the high voltage shunt regulator tube and the cathode-ray tube are presented. A selected 6EF4 tube, under operating conditions chosen to produce maximum X-ray emission, produces an exposure rate of 83 R/hour immediately at the floor level under a console receiver, and a calculated maximum exposure rate of 800 R/hour below the receiver.

The results of using two different methods to measure X-ray exposure rates are given, an ion chamber and X-ray film, and the results compare within reasonable limits. Preliminary findings of X-ray emission from the high voltage rectifier tubes are discussed. Little is known of the mechanisms that cause rectifiers to emit X rays, or how such emissions may be controlled other than by shielding.

Recent testimony at Congressional hearings (1) has publicized the circumstances by which the General Electric Company distributed about 110,000 home color television receivers potentially capable of emitting X rays greatly in excess of the rates recommended by the National Council on Radiation Protection and Measurements (NCRP) (2). The testimony also described the efforts made by that Company, with the assistance of the U.S. Public Health Service, State, and local health agencies, to locate and repair the receivers. The field repair was made by replacing the original high voltage shunt regulator tubes (types 6EA4, 6EF4 and 6LC6) with improved types (6EH4, 6EJ4 or 6LH6), and by readjusting the regulated high voltage supply to the cathode ray tube.

In order that personnel of the National Center for Radiological Health, PHS, might better investigate the problem, GE loaded prototypes of receivers with the KC chassis. Two chassis used the type 6LC6 tube (an octal-

based tube) and two used the type 6EF4 tube ("Compactron"®). The 6EF4 tube was found to be potentially the most hazardous. Tube type 6EA4 is much like the 6EF4 tube, but was used in few of the KC chassis.

This is a report of the operating characteristics of two color television receivers, chassis type KC, equipped with high voltage shunt regulator tubes type 6EF4. Typical operating conditions that affect X-ray leakage from television receivers using high voltage shunt regulators were studied. Using a randomly selected 6EF4 shunt regulator tube, the relationships observed with two different measuring instruments between operating parameters and X-ray exposure rates beneath, at the face plate, and at the sides of a console receiver are described. Under conditions chosen to produce maximum X-ray emission the magnitude of X-ray exposure beneath a receiver from a selected defective 6EF4 shunt regulator tube (No. 72) is presented. Preliminary measurements of X-ray production from the high voltage rectifier tube are discussed.

X-ray exposure rate from the viewing faceplates of the cathode ray tubes under all typical operating conditions produced X-ray exposure rates well below NCRP recommendations.

² Registered Trademark of GE

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The M288CWD is a portable model with a metal cabinet and a molded plastic back. This type is easily mounted on a table, shelf, or brackets, high enough from the floor so that a person might remain underneath it for extended periods close to the bottom of the cabinet. The metal bottom which is not easily removed, shields out all X-rays directed downward from a defective shunt regulator tube, except where the rays may emerge through a series of narrow ventilation slots, or louvers. The emergence and the intensity of the downwardly-directed X rays depend on the exact orientation of the X-ray emission from the defective 6EF4 tube installed in the set. The anode of the shunt regulator (where X rays originate) is 9 cm above the bottom surface of the receiver.

The M970CWD is a console (floor) model, with wood sides about 3 mm thick, and with a hardboard bottom about 6.5 mm thick. There is no metal shielding on the underside of the chassis. This model of the GE receiver, most probably, would remain on the floor. The underside is 22 cm above floor level and the X-ray producing anode of the shunt regulator tube is 9 cm above that, or 31 cm in all, above the floor. Because of the construction of the legs, only objects less than 10 cm high can be inserted under the cabinet from the front and rear. From both sides, an object less than 15 cm high can be inserted under the cabinet for approximately 15 cm. Beyond that, the height limit is 10 cm. The hardboard bottom of the console cabinet attenuates the X-ray beam only slightly (about 44 percent). The slots of the louvers under the shunt regulator tube permit the emergence of an unattenuated X-ray beam.

In both receivers, the high voltage rectifier was placed upside down in a ventilated aluminum cage having a steel back. If X rays are emitted from the high voltage rectifier, they could emerge only from the sides on top of the high voltage cage. Both receivers had thin hardboard or plastic backs. The console model could also readily transmit X rays emitted laterally from the shunt regulator tube.

Definition of terms

Throughout this report, a series of terms, and symbolic abbreviations are used. The fol-

lowing is a list of special terms. Others are explained in the text.

Abbreviation	Units	Description
I _c	milliamperes, ma	Cathode ray, or "picture" tube electron current
I _a	milliamperes, ma	Anode electron current of high voltage shunt regulator tube
I _t	milliamperes, ma	I _c + I _a , total electron current available for regulation
H.V.	kilovolts	High voltage
V _c	kilovolts	Second anode accelerating voltage of cathode ray tube
V _a	kilovolts	Anode to cathode voltage of high voltage shunt regulator tube
VAC	volts, root mean square, 60 Hertz	Household or laboratory line voltage supply
CRT	-----	Cathode ray tube

Typical operating conditions

To measure typical operating conditions of the KC chassis in the console model, a randomly chosen shunt regulator tube (type 6EF4, designated Dallas No. 9), and the original rectifier tube, type 3CN3, were used. Two milliammeters were mounted on an insulating plastic plate, with one used to measure the cathode ray tube current (I_c) and one used to measure the shunt regulator tube anode electron current (I_a). The rated accuracy of the meters was ± 2 percent of full scale, resulting in a reading accuracy of about ± 5 percent. The total current available for regulation (I_t) was the sum of I_c + I_a.

High voltage was measured to ground with an electrostatic voltmeter Model KVE, 0-10, 20, 30, 50 kV, manufactured by Hallmark Standards, Inc. Line voltage was measured at the line cord plug with a 0-150 VAC Weston taut band meter Model 904. The cathode voltage of the shunt regulator tube was measured with a Simpson Model 260-3 volt ohmmeter.

To make a set of measurements, the rear panel high voltage control was set at an arbitrary point. The front brightness control was adjusted to give various values of anode electron current in the shunt regulator tube, from minimum to maximum, while the cathode ray tube current (I_c), cathode ray tube voltage (V_c), shunt regulator tube voltage (V_a), and the line voltage (VAC) were recorded. A dot-bar-color generator maintained a standard pattern on the cathode ray tube. Line voltage was

progressively increased by autotransformer from 90 VAC to 125 VAC.

A series of quasi-linear relationships were observed for V_s , I_r , and I_t with line voltage, showing that the type of high voltage regulation circuit used in the KC chassis regulated only for changes in I_t , and not for changes in line voltage.

Figure 1 shows a typical pattern of V_s , I_r , and line voltage for the GE KC chassis. The normal color picture tube current, I_t , for a new picture tube, may range from 0.22 to 0.80 milliamperes. The remainder of I_t is shunted by the regulator to the B+ bus of the circuit, so that the high voltage remains relatively constant.

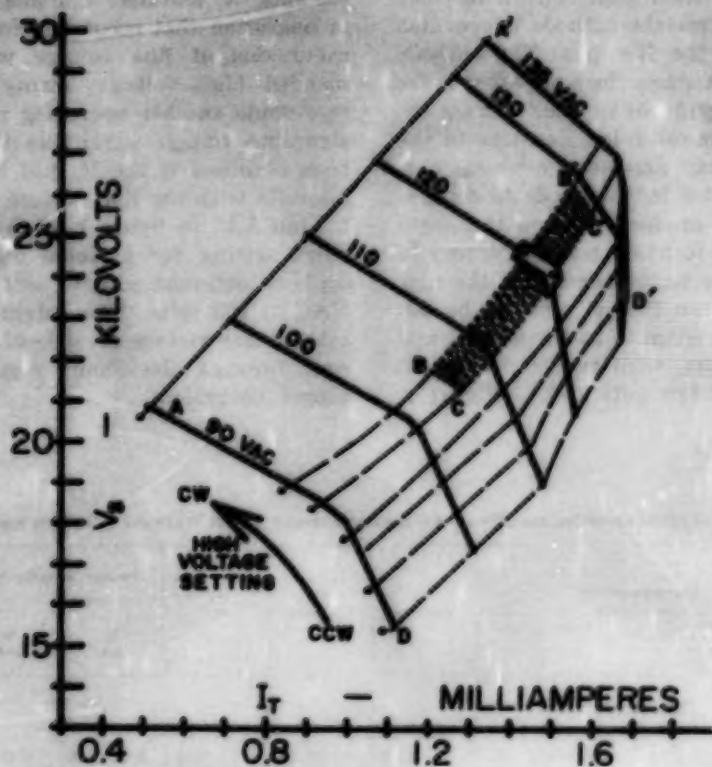


Figure 1. Typical operating conditions of a high voltage shunt regulator tube, type 6EF4 (Dallas #9) in a color television receiver (GE, KC model M970CWD)

AA'—Rear panel H. V. setting for maximum kV

BB'—Rear panel H. V. setting for 24.50 kV at 120 VAC line, the maximum recommended by manufacturer

CC'—Rear panel H. V. setting for 24.00 kV at 120 VAC line, the optimum recommended by manufacturer

DD'—Rear panel H. V. setting for maximum I_t

$$I_t = I_{m1} + I_{m2}$$

Dotted zone—Operation region for ± 10 percent change in VAC line.

When the KC chassis is operated with a constant AC line voltage, the high voltage shunt regulator circuit maintains a practically constant kilovoltage on the second anode of the cathode ray "picture" tube for normal operation. A constant total current, I_t , is maintained available for regulation, the sum of the picture tube current, I_p , and the shunt regulator anode current, I_s .

The high voltage from anode to cathode of the shunt regulator tube, V_s , is about 310-460 volts less than the total high voltage rectified to ground, V_r , because the cathode is operated above ground, on the B+ bus. The cathode DC voltage was 3.4 times the line voltage, the regulator control grid voltage has a total excursion of less than 20 volts, negative to the cathode, so one may assume the anode current, I_s , is accelerated by the anode to cathode voltage, V_s . X-ray production from the shunt regulator tube is a function both of V_s and I_s .

The manufacturer recommends that the rear panel high voltage on the KC chassis be adjusted so that V_r is equal to 24.5 kilovolts, and not over 25 kilovolts, with the 60 Hertz AC line voltage fixed at 120 volts R.M.S. Figure 1,

a plot of V_s versus I_s , for values of line voltage, shows the manufacturers recommended operating point. With V_r set at 24.5 kilovolts, V_s would be 24.00 kilovolts. The manufacturer's design criteria allow for ± 10 percent variation from design centers for line voltage. Using the data given in figure 1, the shunt regulator parameters observed under conditions within normal design range would appear as in table 1.

In figure 1, the values in table 1 fall along the lines CC' and BB'. The line CC' is the range of operation that occurs during ± 10 percent excursions of line voltage with the recommended high voltage setting. The line BB' represents another operating range within design line voltage variations that would have been obtained if the V_r had been set at 25.0 kilovolts with the line voltage at 120 VAC.

Line AA', in figure 1, is the clockwise rear panel setting for extreme high voltage, and could be obtained with $V_r = 24.5$ kilovolts and VAC = 105 volts. This might produce an unsatisfactory picture because of insufficient current through the shunt regulator tube for proper operation.

Table 1. Typical operating conditions of GE console model MBFCWD color television receiver

Line voltage VAC (volts RMS)	V_s (kilovolts)	C_s (kilovolts)	I_t (mA)	Assumed normal ranges	
				I_p (mA)	I_s (mA)
Condition CC'*					
120.7	25.00	25.18	1.50	0.22-0.50	1.27-1.09
120.0	24.50	24.00	1.50	0.22-0.50	1.28-1.00
117.0	23.90	23.30	1.46	0.22-0.50	1.24-0.96
105.3	21.58	21.22	1.27	0.22-0.50	1.05-0.77
Condition BB'*					
120.7	25.00	26.22	1.55	0.22-0.50	1.33-1.05
120.0	25.00	24.50	1.43	0.22-0.50	1.21-0.93
117.0	24.40	24.00	1.39	0.22-0.50	1.17-0.89
105.3	22.11	21.75	1.21	0.22-0.50	0.99-0.71

* Conditions CC' and BB' are shown in figure 1.

The line DD' in figure 1 represents the extreme counter clockwise setting of the rear panel high voltage control for minimum kilovolts and maximum regulatory current, I_r . This setting normally would not be used because the picture tube voltage would be too low to yield a satisfactory picture.

In the region of CC-DD', in figure 1, the power limitations of the high voltage system for each setting have been reached, and the shunt regulator has little control over kilovoltage regulation. This region represents the relationships common to almost all black-and-white television receivers, and those color receivers not having high voltage regulators.

It is of interest to calculate, from figure 1, the care and precision that would be required of a field technician to make a satisfactory high voltage adjustment in accord with manufacturer's recommendations and still insure proper circuit operation. In attempting to make the advised setting of V_r — 24.5 to 25 kilovolts, with 120 VAC, the technician has a range of only 24 to 26.8 kilovolts within which to work before he reaches the upper end of the high voltage adjustment, or loss of regulator control. The accuracy required in measuring kilovoltage is better than one part in 25, or ± 4 percent. Few technicians have high voltage meters rated better than ± 10 percent. If V_r is set erroneously at 26.8 kilovolts, load line AA' applies for line voltage variations. Within normal operating ranges then, the high voltage could reach 29 kilovolts.

Relationship between operating parameters and measured X-ray exposure rates

Tests were conducted to relate electron current and high voltage to measured X-ray exposure rates at 3 locations:

- (a) At the face of the cathode ray "picture" tube, where V_r , the accelerating kilovoltage, and I_r , the electron current, were the factors governing X-ray production,
- (b) Below the receiver, at an angle of about 20° from the vertical axis of the shunt regulator tube where a small intense beam of X rays had been detected with a thin-walled GM counter, and
- (c) At the left side of the console cabinet.

X rays had been detected emerging horizontally from the anode plane of the shunt regulator tube through the left side of the cabinet, and from under the left speaker, in the front, about 30 to 40 cm above floor level. Under all conditions of measurement, exposure rates at the side were twice those at the front.

X-ray production for both (b) and (c) were controlled by V_r , the anode-to-cathode kilovoltage of the shunt regulator tube, and I_r , the tube current.

In all cases, X-ray exposure rates were found to be directly proportional to the electron current being accelerated. All values, therefore, have been normalized to one milliamper and are reported as milliroentgens per milliamper-hour.

Exposure rates were measured with a Victoreen ion chamber model 440 RF. The X-ray energy response of the rate meter over a range of half-value layers of 0.4 to 1.0 mm of aluminum was confirmed by comparison with a Victoreen R-meter having NBS calibration. The instrument was found to be essentially energy independent and to read within 6 percent of true reading when uniformly exposed over the entire chamber at a constant rate.

To measure X-ray exposure rates from the face of the picture tube with the Victoreen 440 RF ion chamber, the tube was operated at several times the normal current and at higher than recommended voltages. The results are given in table 2.

Table 2. X-ray exposure rates from faceplate of picture tube of GE console model M970CWD color television receiver

Accelerating voltage V_r (kilovolts) ^a	Electron current I_r (milliamperes) ^b	X-ray exposure rate (milliroentgens/ milliamper-hour) ^c
30.00	1.00	0.15
28.96	1.00	.10
28.92	1.00	.03

^a This is the gross V_r . No attempt was made to measure the net accelerating voltage by deducting static charge effects.

^b Much of the electron current is intercepted by a perforated iron mask in the picture tube.

^c Victoreen 440 RF ion chamber in contact with faceplate. A full raster with cross-hatch pattern was used.

Because of the low exposure rates at the face of the picture tube attenuation measurements were not made.

To measure the maximum X-ray exposure rates below the receiver, the Victoreen 440 RF was located in the most intense portion of the downward emerging X-ray beam, about 1.2 meters underneath the receiver, which was supported on an elevated frame. A heavy lead mask was fixed about 30 cm below the anode of the shunt regulator tube, the source of the X-rays. The mask had a 7.5 by 7.5 cm aperture which was used to support additional lead collimators and attenuating materials. At 30 cm, practically all of the downward X rays emerged through the 7.5 cm square aperture.

By means of careful masking, the most intense portion of the X-ray beam was localized and was defined by a lead mask with an 0.6 by 0.6 cm aperture placed 15 cm below the anode of the tube, just 5 cm from the lower surface of the console cabinet. The larger lead mask was removed after attenuation measurements were made.

The most intense portion of the X-ray beam, at 117 cm from the tube anode to the center of the ion chamber, was entirely incident on the chamber window, and appeared to fill an area of 22 cm², about 4.4 by 5 cm. Because the beam was not uniform, any extrapolation of the measured values would tend to underestimate actual maximum exposure rates. The area of incident X rays, 22 cm², was 29 percent of the area of the entrance window of the ion chamber. The readings made at 117 cm, therefore, were multiplied by 3.44 to obtain the estimated exposure rates at that distance. These rates, then, were used as the baseline data for extrapolating in toward the source.

The ion chamber was then moved to 64 cm from the shunt tube anode, and the series of exposure rate and attenuation measurements listed in table 4 were made. To prepare table 4, smooth interpolations were made graphically to provide data for whole number values of accelerating voltage. Corrections were made for air attenuation, which was measured at V_a = 24.06 kV and 28.62 kV, by placing the ion chamber at measured distances along the collimated X-ray beam. Except for air absorption, the reading of the ion chamber did not change with distance from the source, as long as the X-rays were totally incident on the entrance window. Attenuation by air, for prac-

tical purposes, appeared to be the same at both voltages, and typical values are given below.

Measured attenuation of 24-28 kV X rays by air

Distance from source, cm	50	75	100	150
Fraction of original exposure rate	0.90	0.86	0.825	0.79

The exposure rate values given in table 3 were calculated from the data obtained at 117 cm and 64 cm for a distance of 30 cm from the shunt tube anode. For known values of V_a and I_a, the readings at 117 cm were multiplied by the factor 3.44 to obtain exposure rate. A correction was applied to allow for the lesser air attenuation at 30 cm, and it was assumed that the corrected exposure rate at 30 cm,

$$R_{30} = R_{117} \times (117)^2$$

(30)

A similar factor was calculated to obtain corrected exposure rates from the measurements made at 64 cm.

In footnotes to table 3 are given the first, second and maximum (heavily filtered) half-value layers in aluminum, and the aluminum equivalent absorber thicknesses of two common building materials.

The maximum exposure rates given in table 3 were confirmed by measurements made with large X-ray films that had been calibrated for X rays in this range of energies, in comparison with cobalt-60 gamma rays. Each 14-inch by 17-inch film, in a paper "ready pack", was exposed 30 cm below the anode of the shunt regulator tube, parallel to the receiver base, masked by lead collimators previously described so that only the most intensely irradiated area was exposed, 4.13 by 4.76 cm. After exposure, the films were given standard development for 5 minutes at 68° F., with nitrogen gas burst agitation. The film was packed with two pieces in each ready pack. Care was taken to have the desired type of film oriented toward the source. After drying, the optical densities were read using a modified Ansco-MacBeth Model 12A densitometer that had a light spot 1.0 mm in diameter. The exposed areas were

Table 3. Maximum X-ray exposure rates at 30 cm below a molybdenum anode 6EF4 high voltage regulator tube operated in GE model M970CWD color television receiver (measured with Victoreen 440 RF ion chamber)

Added attenuation (μ) of Al	Maximum X-ray exposure rates ^a at 30 cm, milliroentgens per milliamperes-hour										
	V ₀ —Shunt tube anode—cathode voltage										
	30 kV	21 kV	22 kV	23 kV	24 kV	25 kV	26 kV	27 kV	28 kV	29 kV	30 kV
0.00	52.30	44.70	39.10	34.50	30.00	277.0	343.0	328.0	440.0	577.0	692.0
.25	5.24	30.30	29.70	47.00	72.00	108.0	157.0	219.0	304.0	438.0	599.0
.50	4.21	9.48	18.15	30.50	49.50	77.50	117.0	168.0	242.0	338.0	483.0
.75	2.44	5.45	11.05	19.80	36.00	55.90	83.30	135.0	194.5	275.0	376.0
1.00	1.85	3.64	7.25	14.30	26.70	45.70	74.70	112.0	163.0	231.0	318.0
1.25	0.78	1.82	4.15	8.18	15.90	30.50	50.30	78.40	117.0	171.3	242.0
2.00	.33	0.97	2.41	5.12	10.06	19.90	34.30	55.40	86.10	127.7	186.2
3.00		.59	0.79	1.85	4.14	8.25	15.70	27.40	44.50	70.30	105.7
4.50			.38	0.68	1.73	3.96	7.68	14.70	25.05	40.90	65.10
6.00				.25	0.77	1.88	3.98	7.82	14.34	24.40	39.90
8.00					.38	0.90	3.01	4.87	8.35	14.34	24.35
9.00						.43	1.08	3.44	4.82	8.74	15.00
9.00						.30	0.53	1.23	2.99	5.10	9.06
9.00							.36	0.73	1.53	2.97	5.06
Half-value layers ^b in mm of aluminum:											
HVL ₁	0.06	0.13	0.15	0.24	0.33	0.39	0.44	0.53	0.58	0.68	0.74
HVL ₂	.11	.19	.30	.58	.51	.67	.83	.90	1.01	.97	1.23
HVL _{max}	.43	.64	.68	.73	.83	.94	1.08	1.14	1.23	1.33	1.41

^a The aluminum equivalents of two common building materials were:
Douglas fir interior grade plywood—0.334 mm of Al/cm
Framed fiber ceiling tile—0.315 mm of Al/cm

^b Measurements made at 30 cm from anode, 30° from base end of long axis of tube.

scanned by hand, to locate the area of maximum exposure, which was almost uniform over an area measuring about 1.0 by 1.3 cm. Table 4 summarizes the findings.

A comparison of the results of tables 3 and 4 (the appropriate table 3 values are given in footnote ^a of table 4), showed reasonably good agreement between the values calculated from ion chamber measurements and those obtained on the slow "commercial" film, at both 28.62 kV and 24.07 kV. The "commercial" film gave 15 percent lower results at 28.62 kV and 5 percent lower at 24.07 kV, values that seemed to be in excellent agreement with those calcu-

lated from ion chamber readings. The fast "KK" film also gave results lower than calculated, 31 percent at 28.62 kV and 25 percent at 24.07 kV, about the lower extreme of substantial confirmation by this method.

Radiation emitted from the left side of the receiver console (about 0.32 cm of hardboard or plywood) was also evaluated with the Victoreen 440 RF ion chamber. With the chamber face 0.6 cm from the cabinet, aimed at the anode-cathode region of the shunt regulator tube, the center of the chamber was 31.4 cm from the anode of the tube. A lead-steel collimator with a 10 cm by 10 cm opening was

Table 4. Maximum X-ray exposure rates at 30 cm below a molybdenum anode 6EF4 high-voltage regulator tube operated in GE model M970CWD color television receiver (measured with X-ray film)

Type of X-ray film (Eastman Kodak Company)	V ₀ ^a (kV)	HVL ₁ (mm of Al)	Energy dependence factor rel. to cobalt-60	Maximum optical density			Exposure time (minutes)	Equiv. cobalt-60 exposure (mR)	Calculated	
				Gross	Base and fog	Net			X-ray exposure (mR)	X-ray exposure rate (mR/ mA-hr) ^b
"KK"	28.62	0.75	0.117	0.50	0.24	0.26	1.2	63	7.25	363
"Commercial"	28.62	.73	.117	.44	.06	.38	50	3200	374.4	449
"KK"	24.07	.35	.185	.38	.23	.16	4.0	40	7.40	111
"Commercial"	24.07	.35	.185	.30	.06	.22	150	1900	351.5	141

^a I₀=1.00

^b The equivalent rates, from table 3, are 528 and 148 mR/mA-hr at 30 cm, respectively.

Table 5. X-ray exposure rates at 31.4 cm, laterally from a molybdenum anode 6EF4 high-voltage regulator tube operated in a GE model M970CWD color television receiver (measured with a Victoreen 440 RF ion chamber)

Added attenuation t (mm of Al)	X-ray exposure rates * at 31.4 cm, mR/mA-hour										
	V _o —shunt tube anode—cathode voltage										
	20 kV	21 kV	22 kV	23 kV	24 kV	25 kV	26 kV	27 kV	28 kV	29 kV	30 kV
0.00	0.055	0.070	0.091	0.120	0.165	0.230	0.335	0.510	0.800	1.30	2.20
1.00						.026	.063	.147	.282	0.53	0.91
2.00						.0124	.032	.080	.163	.31	.55
3.00							.016	.044	.093	.18	.34

* Measurements made laterally opposite anode-cathode, on outside of left side of receiver.

placed in the cabinet half way between the anode and the chamber. Unattenuated readings were made at about 50 values of V_o , and attenuation measurements were made at 28.65 kV and 24.07 kV. The X rays from the side were semihomogeneous in a broad horizontal, slightly downward band, and covered the entire chamber window. The exposure rates appeared to follow the inverse square law with increasing distance out to at least 50 centimeters. Table 5 lists the observed exposure rates, smoothed graphically as was done for table 3, to give values for whole numbers of V_o , the shunt tube anode-to-cathode voltage.

Graphically, comparison of the attenuated side radiation and the attenuated downward radiation for ratios of exposure rates at 28.65 kV and 24.07 kV showed that the side radiation had the attenuation characteristics of downward X rays that had been filtered by an additional 3.0 or 4.0 millimeters of aluminum equivalent, but numerically 6 percent of the equivalent downward value. Below 1.0 mm of added aluminum attenuator, the side radiation had "soft" radiation components that concealed the essentially "hard" nature of these X rays in comparison to the "softer" nature of those emerging downward.

X-ray exposure rates through the front of the cabinet under the left speaker were similar in characteristic to the side radiation, and were one-half the side exposure rates listed in table 5.

X-ray exposure from shunt regulator tube under operating conditions producing maximum X-ray emission

The portable model represents a case where the highest exposure rate might occur because

human tissue such as the eye, can be placed within about 10 to 12 cm of the anode of the shunt regulator tube. The area of exposure, however, is small.

The console model represents the case where the maximum area (and volume) of exposed tissue might occur because the underside of the set offers little shielding.

Three conditions of exposure were examined at the Electronic Products Radiation Laboratory. The assumption was made that the same exposure rate was possible below both models of GE color television receivers:

(1) exposure 85.1 cm below the anode of the shunt regulator tube of a floor mounted console receiver, with intervening floor and ceiling equivalent material,

(2) exposure 31 cm below the anode of the shunt regulator tube in the floor mounted console receiver at the upper surface of the floor, and,

(3) exposure 10 cm below the anode of the shunt regulator tube of a floor mounted console receiver, very close to the underside of the cabinet. Except that the area exposed is much larger, this would also simulate the exposure rate at the closest approach to the portable model. Significantly, from this position one can look through the ventilating louvers and see the glowing anode of the shunt regulator tube because the tube is mounted in a cut-out position with no intervening material between the anode and the eye.

The GE color television receiver, model M970CWD console, was operated with a type 6EF4 shunt regulator tube designated experimentally as No. 72, under the following conditions.

Screen brightness—minimum, operation otherwise normal

Signal input—programmed channel

V_a , approximate kV at 6EP4 anode—24.5 kV positive with respect to chassis ground ($V_a = 24.09$ kV)

I_a , anode current—1.4 mA

Line voltage—117 VAC, 60 Hertz

The console receiver was placed on a platform of plywood 0.65 cm thick, which in turn, was elevated 58.3 cm above a concrete floor. The X-ray pattern emerging through the bottom of the set was located and marked.

Measurements were made with paper packages of 14- by 17-inch X-ray film, each containing one fast (Eastman Kodak Company KK) and one slow (Eastman Kodak Company Commercial) non-screen film. The film was processed using standard developing procedures with gas burst agitation. Energy dependence and exposure calibrations were confirmed by the X-ray Exposure Control Laboratory, National Center for Radiological Health. Optical densities were read with a MacBeth-Anasco Densitometer, model 12A, having a light beam 4.0 mm in diameter.

(1) One film pack was exposed, centered on the X-ray pattern, for 30 minutes, 85 cm below the anode of the shunt regulator tube and 54 cm below the surface of the supporting floor. In addition to the shielding provided by the 0.65 cm plywood floor, a layer of 1.91 cm Douglas fir, interior grade plywood and a layer of 1.27 cm compressed fiber acoustic ceiling were added to simulate flooring and ceiling typical of some types of house construction.

(2) One film pack was exposed and centered on the X-ray pattern for 30 minutes, 31 cm below the anode of the shunt regulator tube, on the surface of the supporting floor of 0.65 cm plywood. No intervening shielding except that of the hardwood underside of the TV receiver was present.

(3) From the data obtained in (2), using the inverse square law, the maximum exposure rate 10 cm below the anode of the shunt regulator tube in the floor mounted console receiver was

calculated. This is approximately the nearest that human tissue could be placed to the underside of the cabinet.

$$83,200 \text{ mR/hr } (31)^2 / (10)^2 = 800,000 \text{ mR/hr (at 10 cm)}$$

The measured intensities, 640 mR/hr at 85 cm, and 83,200 mR/hr at 31 cm, and the calculated intensity, 800,000 mR/hr at 10 cm, were used to construct the curves on the graph shown in figure 2. The transmission factors of the floor and ceiling material² were measured by a Victoreen 440 RF ion chamber corrected for exposure area. The "inverse square" curve was calculated from the point (31 cm, 83.2 R/hr). The free air curve was measured below the television receiver with the Victoreen 440 RF, using a very narrow X-ray beam (4.4 by 5.0 cm). The beam intensity decreases the "inverse" faster than the "square" curve inverse square of distance because of air absorption and scatter. The film measurement of 640

² X-ray transmissions of simulated floor of 2.54 cm plywood = 21.4 percent
X-ray transmission of ceiling of 1.27 cm pressed fiber = 68.3 percent
Total transmission of floor-ceiling combination = 14.6 percent

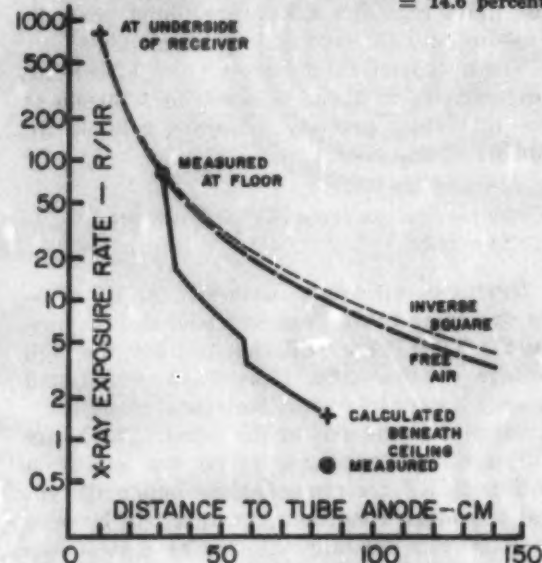


Figure 2. X-ray exposures beneath a GE console color television using type 6EP4, No. 72, regulator tube. Measurements were made with X-ray film at 25 cm below the tube and 85 cm below the tube. All other values were calculated from measured transmission data.

Film data (maximum reading):

Film type	Exposure time (minutes)	Net optical density	Equivalent cobalt-60 exposure (mR)	Assumed half-value layer (mm Al eq.)	Energy correction factor	Corrected exposure (mR/hr)
Commercial	30	0.34	2,000	0.46	0.16	640

Film data (maximum reading):

Film type	Exposure time (minutes)	Net optical density	Equivalent cobalt-60 exposure (mR)	Assumed half-value layer (mm Al eq.)	Energy correction factor	Corrected exposure (mR/hr)
Commercial	30	3.63	160,000	0.20	0.26	83,260

mR/hour at 85 cm was 98.5 percent the expected value, 1,470 mR/hour, that had been calculated from attenuation measurements.

A further test was made to relate scattered radiation to the primary exposure at the floor. Three 14- by 17-inch X-ray films were placed vertically against the cabinet and touching the floor, one on the left side and two on the left front, with the same exposure setup as in (3). Exposure time was 87 minutes. The maximum exposure rates attributable to the X rays from the shunt regulator tube were found near the floor on both the side and left front films.

The maximum rates were 1.6 and 2.2 mR/hr, respectively, or about 1/50,000 to 1/30,000 of the maximum primary exposure rate at the surface of the floor.

X-ray production from the high voltage rectifier tube

During detailed examination of the KC chassis operating in the console model and employing the NaI (TI) scintillation detector, the high voltage rectifier tube, type 3CN3, was found to emit X rays in a wide, horizontal plane (perpendicular to the axis of the tube). The X-ray exposure rate appeared to be low and well within NCRP recommendations under all typical operating conditions, particularly because the tube was partially shielded by a steel flap on the rear of the high voltage cage.

To investigate the condition further, the rear of the case was opened and the time distribution of the X-ray emissions was examined. Typically in the KC chassis, the high voltage pulse which

lasts 63.5 microseconds, oscillates 4 or 5 times during the peak inverse cycle across the high voltage rectifier. X rays, in very short bursts, are emitted at the peak of each inverse ripple when the peak inverse voltage may be 30,000 volts. The quantity of X rays was greatest during normal viewing conditions and practically unaffected by changes in front panel brightness or contrast control settings. Instead, the emission seemed to be characteristic of the individual tube and not of the exciting supply, except for the frequency of bursts and the high voltage setting.

The time distribution was found by phase angle analysis of the scintillation detector output with a Victoreen "PIP" 400 channel pulse height analyzer. A linear, 0-10 volt ramp, synchronized to the TV flyback pulse, was used to drive the analog-to-digital converter. A variable-delay pulser and a dual-beam oscilloscope were used to determine the time-location of each X-ray peak relative to the shape of the high voltage flyback waveform.

Later, the high voltage cage of this particular KC chassis was modified to permit the examination of other types of 3-volt high-voltage rectifier tubes. The relative pattern of X-ray production was always the same.

Figure 3 shows the X-ray emission from a type 3BS2 rectifier tube operated in the KC chassis in relation to the flyback pulse waveform. The half-value layer of this radiation in aluminum was found to be 1.00 mm, and constant out to 6 half-value layers for black-and-white TV high voltage rectifiers. The greatest quantity of X rays, in fact, was pro-

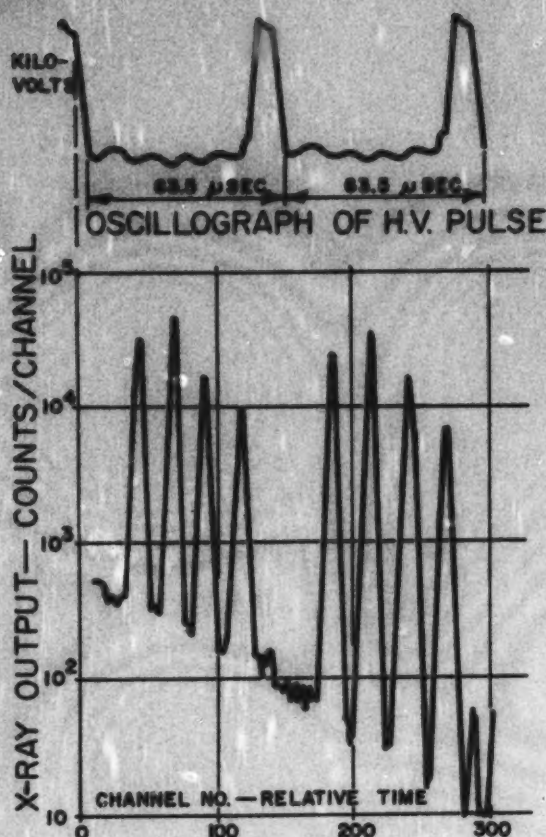


Figure 3. X-ray production during normal operation of high voltage rectifier tube, type 3BS2
 TOP—Oscillograph of the high voltage flyback pulse in a color television receiver (GE KC model M970CWD)
 BOTTOM—Frequency and relative intensity of short bursts of X rays emitted by rectifier during peaks of inverse voltage.

duced by a series of 1-volt filament tubes operating in a 17 kilovolt black-and-white receiver.

A rectifier with a cold filament emits only a single small burst of X rays during the fly-back cycle, when the forward voltage is enough to induce conduction. There is no emission at inverse peaks.

Further testing is planned to devise a way of relating X-ray exposure rates to measurable variables in the high voltage rectifier system in order that quality control methods may be proposed.

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Representative products and manufacturers are named for identification only, and listing does not imply endorsement by the Public Health Service and the U.S. Department of Health, Education, and Welfare.

Technical Notes

Disposal of Radioactive Wastes From U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1966

M. E. Miles and J. J. Mangano¹

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm the adequacy of waste disposal limits and procedures. The waste disposal data presented show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships was 0.39 curies in all harbors in 1966, which is substantially less than the total of 5.38 curies reported discharged in harbors during 1965. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that, (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity is detectable in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public.

A detailed description of the means of disposing of radioactive wastes and the sources of these wastes has been presented earlier (1). Table 1 lists the total amounts of long-lived radioactivity discharged as liquid wastes into various U.S. harbors during 1965 and 1966. Solid radioactive materials from ships are transferred to a shipyard or other shore facility for packaging and disposal. For ultimate disposal, solid radioactive wastes are shipped to AEC-approved burial sites since shipyards and shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. The total radioactivity and volumes of solid radioactive wastes disposed of in 1965 and 1966 are shown in table 1.

Environmental monitoring survey procedures have been described in a previous report (1). A summary of the 1966 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built is presented in table 2.

Monitoring for cobalt-60 in harbor bottom sediment is conducted each quarter year by collecting 20 to 100 samples with a 6-inch square sampler. Samples are taken of the top one-half to one inch of sediment in the immediate vicinity of and away from berthing areas used by Naval nuclear-powered ships. These surveys show that the total amount of cobalt-60 observed in bottom sediment near a few piers is small compared to natural radioactivity present in harbors.

Independent checks on sediment have been performed by the U.S. Public Health Service by analyses performed at the Southeastern Radio-

¹ Nuclear Propulsion Divisions, Naval Ship Systems Command, Department of the Navy.

Table 1. Radioactive waste disposed by U.S. Naval nuclear-powered ships and their support facilities *

Location	Solid radioactive waste				Liquid radioactive waste ^b			
	1963		1966		1965		1966	
	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Thousand gallons	Curies	Thousand gallons	Curies
1. Portsmouth, N.H. Naval Shipyard.....	160	2.6	196	9.9	204	0.34	165	0.01
2. Quincy, Mass. Quincy Division.....	0	0	0	0	0	0	0	0
3. Groton-New London, Conn. Electric Boat Div., State Pier, and Submarine Base.....	121	955.0	148	1,093.8	299	1.39	1,374	.05
4. Camden, N.J. New York Shipbuilding Corp.....	0	0	0	0	0	0	0	0
5. Newport News, Va. Newport News Shipbuilding.....	196	26.0	70	8.0	2,380	1.70	1,961	.06
6. Norfolk, Va. Naval Shipyard and Base.....	32	1.6	42	2.6	1,166	.64	1,061	.03
7. Charleston, S.C. Naval Shipyard and Base.....	78	111.5	77	6.6	717	.67	390	.04
8. Pascagoula, Miss. Ingalls Shipbuilding Corp.....	0	0	0	0	0	0	0	0
9. San Diego, Calif. Navy Pier at Ballast Point.....	3	0	6	.1	40	.32	0	0
10. Vallejo, Calif. S.F. Bay Naval Shipyard.....	47	6.4	90	267.0	126	.31	270	.16
11. Bremerton, Wash. Puget Sound Naval Shipyard.....	4	.1	14	.5	196	.01	0	0
12. Pearl Harbor, Hawaii Naval Shipyard and Base.....	8	1.4	7	.3	545	.42	624	.08
13. Apra Harbor, Guam.....	0	0	0	0	60	.01	0	0
Total.....	676	507.6	641	1,487.2	7,328	5.36	5,354	0.30

* U.S. harbors where shipyards and operating bases for nuclear-powered ships are located are included. Other U.S. harbors have had less than 20,000 gallons and less than 0.1 curies discharged per year.

^b Where discharges in one harbor for a year totaled less than 0.005 curies, "0" is reported in this table. Volumes are reported prior to dilution. Radioactivity data has been standardized to cobalt-60.

Table 2. Summary of 1966 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built

Location	Number of samples with cobalt-60 concentration of: (pCi/cm ³)			Total bottom area with cobalt-60 over 10 pCi/cm ³ (km ²)	Estimated total cobalt-60 in top layer of sediment * (Ci)
	<10	10-100	>100		
1. Portsmouth, N.H. Naval Shipyard.....	174	1	0	0.001	0.007
2. Quincy, Mass. Quincy Division.....	40	0	0	ND	ND
3. Groton-New London, Conn. Electric Boat Div., State Pier, and Submarine Base.....	58	215	76	.3	.3
4. Camden, N.J. New York Shipbuilding Corp.....	61	0	0	ND	ND
5. Newport News, Va. Newport News Shipbuilding.....	148	0	0	ND	ND
6. Norfolk, Va. Naval Shipyard and Base.....	341	3	0	.001	.001
7. Charleston, S.C. Naval Shipyard and Base.....	367	1	0	.001	.001
8. Pascagoula, Miss. Ingalls Shipbuilding Corp.....	70	0	0	ND	ND
9. San Diego, Calif. Navy Pier at Ballast Point.....	107	34	0	.01	.001
10. Vallejo, Calif. S.F. Bay Naval Shipyard.....	436	1	0	.001	.001
11. Bremerton, Wash. Puget Sound Naval Shipyard.....	140	0	0	ND	ND
12. Pearl Harbor, Hawaii Naval Shipyard and Base.....	180	100	4	.3	.08
13. Apra Harbor, Guam.....	75	0	0	ND	ND

* All areas with detectable cobalt-60 were in immediate vicinity of piers used for berthing nuclear-powered ships. Minimum detectable radioactivity is approximately 5 pCi/cm³. ND, not detectable. Where total cobalt-60 is less than 0.001 curies, "ND" is reported.

logical Health Laboratory, Montgomery, Ala., on two samples from each of these harbors each quarter. In addition, a U.S. Atomic Energy Commission laboratory checks some samples from each harbor. Results of these checks have been consistent with results reported in table 2.

Once each quarter, a total of at least five water samples is taken at various locations in each harbor in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross radioactivity and for cobalt-60. No harbor water sample has shown detectable cobalt-60 radioactivity. No increases in gross radioactivity of harbor water have been detected.

Twice per year shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive radiation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were in the range of 0.01 to 0.05 millirem per hour, the same as background radiation levels in similar areas.

Throughout the year film badges are posted at locations outside the boundaries of areas where radioactive work is performed. These films showed that radiation exposure to the general public outside these facilities was not above that received from natural background radiation levels.

In addition to the locations listed in table 2, environmental monitoring has been accomplished by U.S. Navy submarine tenders which serve as operating bases for U.S. Naval nuclear-powered submarines in Rota, Spain, and Holy Loch, Scotland. Results of the surveys in the harbor at Rota, Spain, have not shown detectable cobalt-60 in harbor bottom sediment samples. In 1965 in Holy Loch, more cobalt-60 radioactivity than expected was detected in harbor bottom sediment and on shoreline mud flat areas uncovered at low tide. However, there had been no increase of harbor water radioactivity in Holy Loch above normal background levels. Joint U.S. and British assessments of survey results confirmed that radiation levels in the vicinity of the Holy Loch anchorage were far below those which were at all likely to cause an individual to receive radiation exposure approaching limits for members of the general public. Environmental monitoring during 1966 showed radioactivity levels in Holy Loch are steadily declining.

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SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (1-3). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is

a need to initiate careful evaluation of exposure (3). Additional guidelines are provided by the FRC Protective Action Guides (4) and by the International Commission on Radiological Protection (5,6).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide

levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program
Radionuclides in milk, HASL

Period reported
July-December 1966

Last presented
September 1967

1. Pasteurized Milk Network August 1967

National Center for Radiological Health and
National Center for Urban and
Industrial Health, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent de-

scription of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error * (pCi/liter)	Concentration (pCi/liter)	Error * (percent of concentration)
Strontium-90	< 50	5	≥ 50	10
Strontium-90	< 30	3	≥ 30	10
Iodine-131	< 100	10	≥ 100	10
Cesium-137	< 100	10	≥ 100	10
Barium-140	< 100	10	≥ 100	10

* Two standard deviations.



Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of sulfonamides in pastureland soils for the second quarter 1967 and August 1967.

[illegible]

* Blank indicates no strontium-90 determinations were made on samples from station during month.

Figure 1

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium-90, 5; strontium-90, 2; cesium-137, 10; barium-140, 10; and iodine-131, 10. At these levels and below, the counting error comprises nearly all of the analytical error. The results for August 1967, and the second quarter of 1967, are presented in table 2. The average

monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations, averages were calculated using one-half the minimum detectable values; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels. Because all values for iodine-131 and barium-140 were below minimum detectable concentrations during the period covered in this report, results for these two radionuclides have not been included in table 2.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in

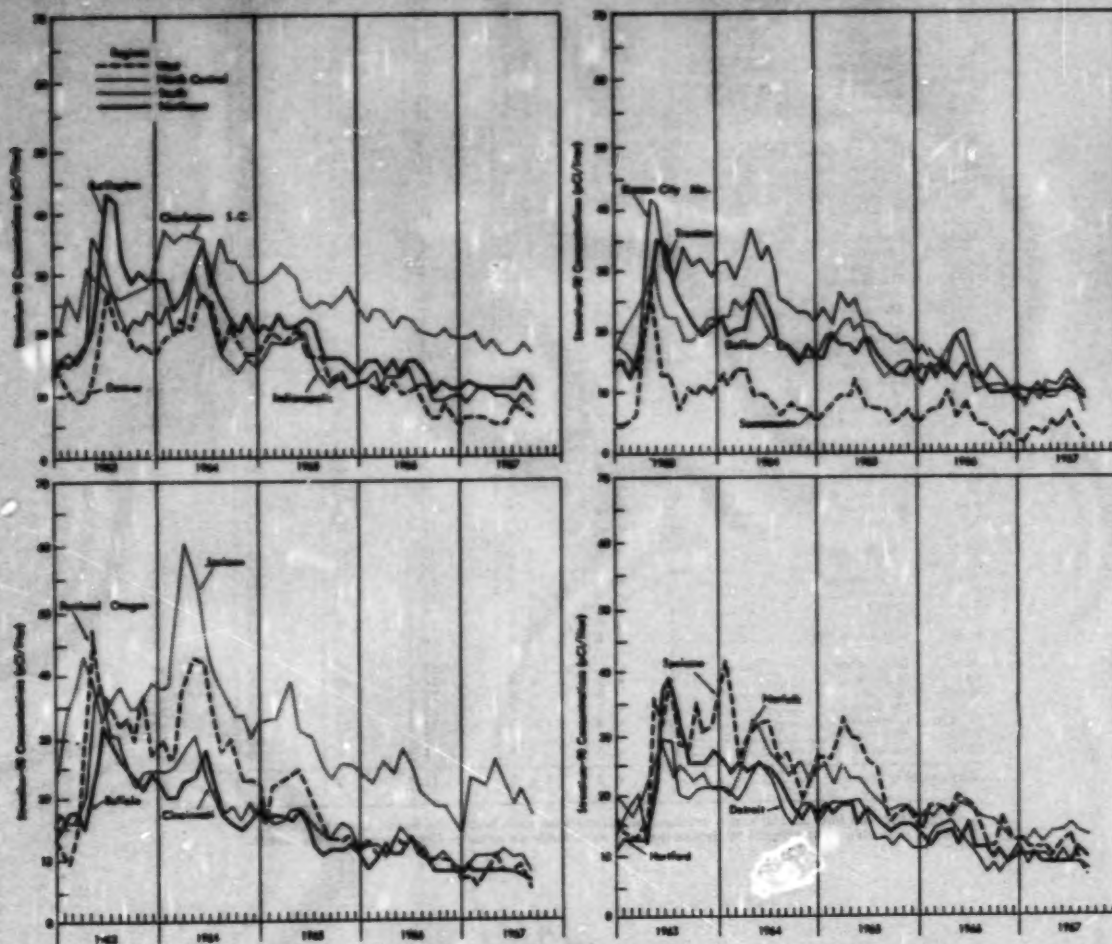


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-August 1967

Schlar 3 and 4 for August 1966, and March through August 1967. The average strontium-

90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium-90 concentrations in milk at PMN stations, August 1966, March-August 1967

Strontium-90 (pCi/liter)	Number of stations *						
	1966	1967					
	August	March	April	May	June	July	August
Under 10.....	15 (34)	26 (40)	26 (40)	22 (40)	27 (42)	25 (40)	25 (55)
10-19.....	40 (89)	25 (38)	34 (54)	33 (58)	34 (54)	25 (38)	28 (42)
20-29.....	7 (11)	2 (2)	4 (6)	3 (5)	2 (2)	3 (5)	2 (3)
30-39.....	1 (3)	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

* Percentage of stations shown in parentheses.

Table 4. Frequency distribution, cesium-137 concentrations in milk at PMN stations, August 1966, March-August 1967

Cesium-137 (pCi/liter)	Number of stations *						
	1966	1967					
	August	March	April	May	June	July	August
Under 50.....	55 (89)	62 (98)	62 (98)	61 (97)	61 (97)	61 (97)	61 (97)
50-99.....	6 (9)	1 (2)	1 (2)	2 (3)	2 (3)	2 (3)	2 (3)
100-149.....	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

* Percentage of stations shown in parentheses.



Figure 3. Canadian milk sampling stations

2. Canadian Milk Network August 1967¹

Radiation Protection Division, Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and

¹ Prepared from September 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The August 1967 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, August 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary.....	1.13	1.4	11	20
Edmonton.....	1.00	1.4	8	28
Ft. William.....	1.00	1.5	15	22
Fredericton.....	1.00	1.5	17	38
Halifax.....	1.11	1.6	17	32
Montreal.....	1.07	1.6	9	26
Ottawa.....	1.08	1.6	8	21
Quebec.....	1.08	1.5	18	32
Regina.....	1.07	1.4	7	16
St. John's, Nfld.....	1.12	1.5	32	110
Saskatoon.....	1.09	1.5	8	23
Sault Ste. Marie.....	1.08	1.5	17	43
Toronto.....	1.10	1.5	4	17
Vancouver.....	1.15	1.5	15	50
Windsor.....	1.10	1.5	5	13
Winnipeg.....	1.14	1.6	8	25
Average.....	1.10	1.5	12	33

3. Pan American Milk Sampling Program August 1967

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures em-

ployed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).

Table 6 presents stable potassium, strontium-89, strontium-90, and cesium-137, monthly average concentrations for August 1967.

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- (3) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704-705 (December 1966).



Figure 4. Pan American Milk Sampling Program stations

Table 6. Stable element and radionuclide concentration in PAHO milk - August 1967

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile: Santiago	5	1.6	5	3	12
Colombia: Bogota	1	1.5	5	3	< 5
Ecuador: Quisaculi	1	1	5	< 1	5
Jamaica: Mandeville	1	1.4	5	5	130
Canal Zone: Cristobal ^b	5	-----	< 5	4	30
Puerto Rico: San Juan ^b	5	-----	< 5	5	10

^a Iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples.

^b For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone and San Juan, Puerto Rico, from the Pasteurized Milk Network are presented.

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current sur-

veillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows those States which report milk surveillance activities in *Radiological*

Health Data and Reports. States having programs appearing in this issue are highlighted in the figure. A summary of State programs previously covered, the reporting period, and issue of appearance is as follows.

<u>State milk network</u>	<u>Period reported</u>	<u>Last presented</u>
Colorado	April-June 1967	October 1967
Connecticut	April-June 1967	November 1967
Florida	April-June 1967	October 1967
Indiana	April-June 1967	November 1967
Iowa	April-June 1967	November 1967
Michigan	April-June 1967	November 1967
Minnesota	April-June 1967	November 1967
New York	April-June 1967	November 1967
Oklahoma	April-June 1967	October 1967
Pennsylvania	April-June 1967	November 1967
Tennessee	April-June 1967	October 1967
Texas	April-June 1967	October 1967

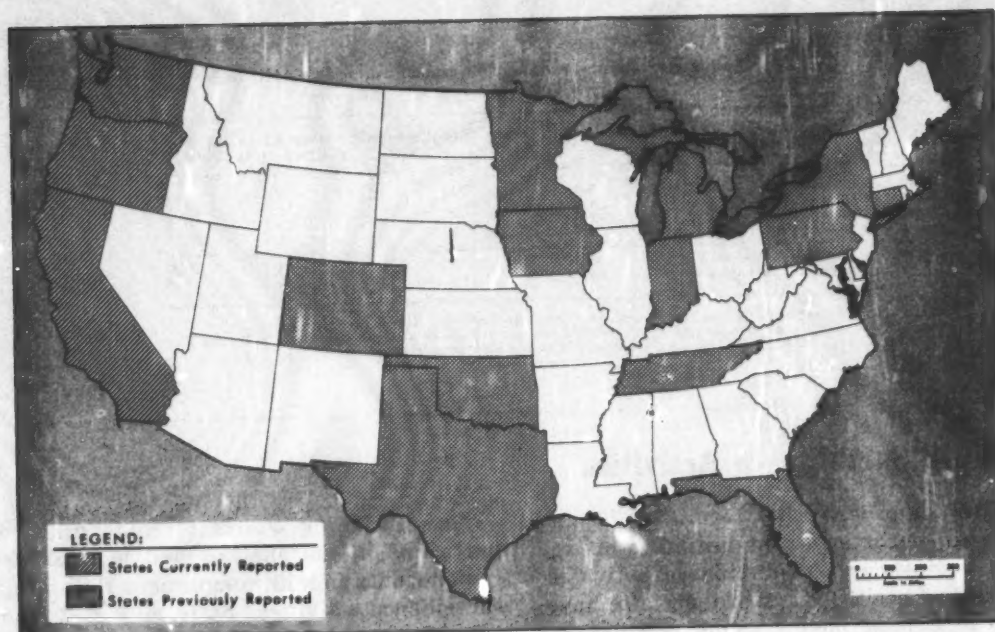


Figure 1. Reported State milk programs

1. California Milk Network April-June 1967

Division of Environmental Sanitation, State of California, Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk monitoring function is conducted by the Department's Bureau of Radiological Health at 10 major milksheds (figure 2).

In January 1960, the eight original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. The Del Norte and Mendocino milksheds were added to the program in March 1962 and since that time weekly, biweekly or monthly sampling of pasteurized

milk has been conducted in 10 milkshed areas of the State. A description of the various California milksheds was presented earlier by Healep and Cornish (1).

Strontium-90 and strontium-90 concentrations are determined radiochemically. Potassium-40, iodine-131, cesium-137, and barium-140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (2).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of April to June 1967. Iodine-131 was below the detectable limit for all stations for this period.

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 3.

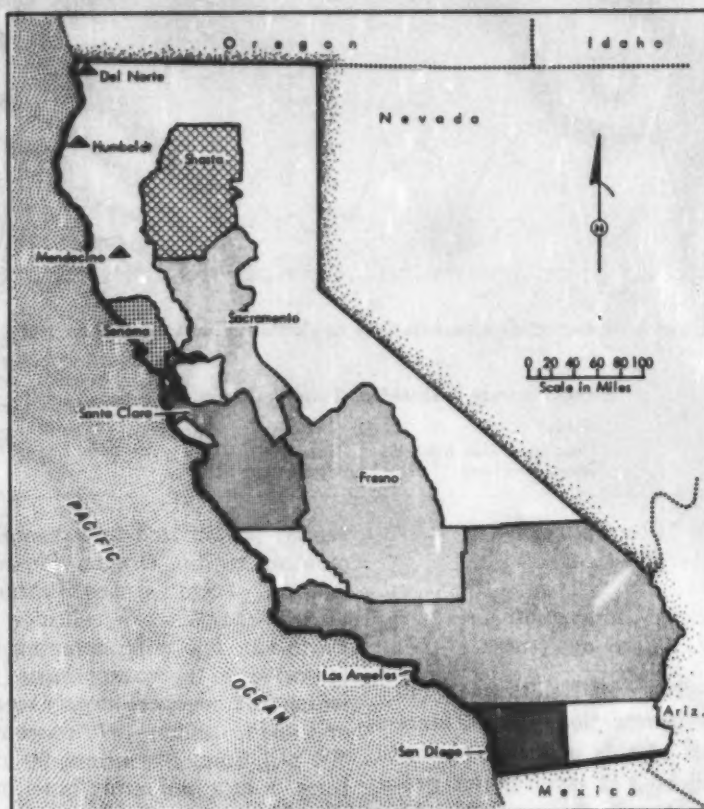


Figure 2. California milksheds

Table 1. Stable element and radionuclides in California milk, April-June 1967

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	April	May	June	April	May	June	April	May	June	April	May	June	April	May	June	April	May	June
Del Norte	1.32	1.34	1.36	1.127	1.080	1.120	85	27	0	26	25	22	44	26	23	20	29	ND
Fresno	1.17	1.19	1.23	1.141	1.187	1.108	2	4	ND	2	2	2	11	13	13	21	19	ND
Fullerton	1.22	1.20	1.15	1.133	1.143	1.082	22	18	2	2	2	2	16	13	13	18	27	ND
Los Angeles	1.24	1.11	1.10	1.064	1.061	1.170	ND	2	1	1	2	10	6	16	14	39	29	ND
Merced	1.20	1.11	1.11	1.170	1.155	1.090	12	7	0	1	5	4	31	15	NA	45	25	ND
Sacramento	1.21	1.24	1.05	1.087	1.120	NA	ND	1	ND	2	2	2	16	15	16	16	16	ND
San Diego	1.18	1.10	1.14	1.110	1.129	1.076	ND	1	ND	2	2	2	6	6	18	15	1	ND
Santa Clara	1.15	1.18	1.16	1.104	1.120	1.090	1	ND	2	2	2	4	6	18	15	1	28	ND
Shasta	1.11	1.15	1.16	1.118	NA	1.080	4	0	0	4	4	4	10	NA	22	22	NA	ND
Sonoma	1.20	1.12	1.13	1.250	1.090	1.118	14	0	4	5	9	7	25	16	17	45	30	ND
Average	1.17	1.18	1.14	1.175	1.148	1.108	12	8	3	6	7	7	17	15	14	24	20	3

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
ND, nondetectable.
NA, no analysis.

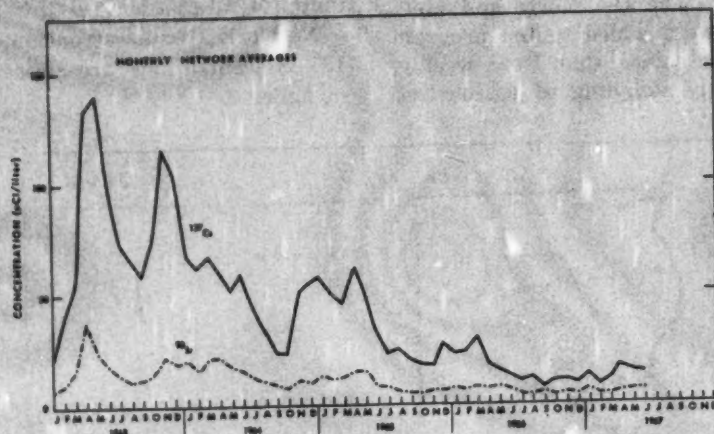


Figure 3. Radionuclide concentrations in California milk, 1963-June 1967

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	June 1967
January-March 1967	September 1967

2. Oregon Milk Network April-June 1967

*Division of Sanitation and Engineering
Oregon State Board of Health*

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at seven major production areas (figure 4), which supply 90 percent of the milk distributed in Oregon. Cur-

rently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or when cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

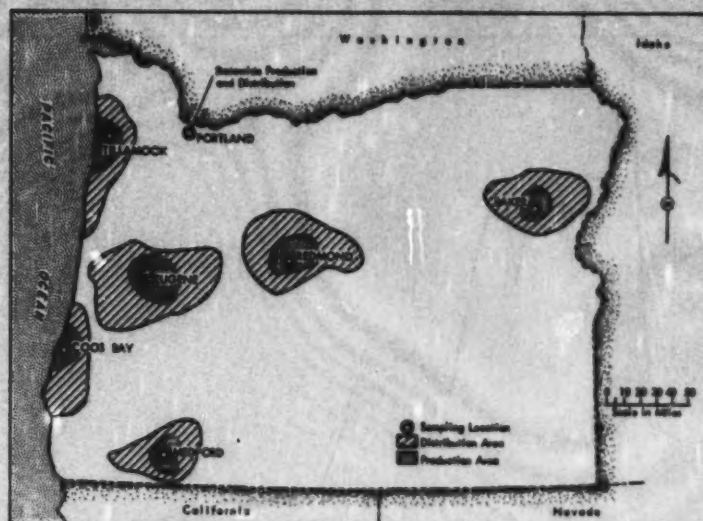


Figure 4. Oregon milk production and distribution areas

Strontium-90 concentrations are determined using a trichloroacetic acid analytical procedure (3). Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry (4).

Table 2 gives the strontium-90 and cesium-137 concentrations in pasteurized milk from April through June 1967. These data are presented graphically in figure 5. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter for all samples which were collected in April

through June 1967. Anticipated increases of radioactivity in milk from the Chinese nuclear test on June 17, 1967, were not observed during this period.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	June 1967
January-March 1967	September 1967

Table 2. Radionuclide concentrations in Oregon pasteurized milk, April-June 1967

Location	Sampling frequency *	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		April	May	June	April	May	June
Baker	M	NS	10	NS	<15	15	<15
Coos Bay	M	NS	17	NS	26	25	43
Eugene	M	NS	14	NS	16	30	18
Medford	M	NS	8	NS	<15	<15	56
Portland composite	W	11	8	8	38	22	16
Portland local	W	NS	19	NS	35	35	35
Redmond	M	NS	8	NS	NS	30	21
Tillamook	M	NS	NS	NS	23	NS	118
Average		11	12	8	24	22	42

* M, sampled monthly, W, sampled weekly.
NS, no sample collected.

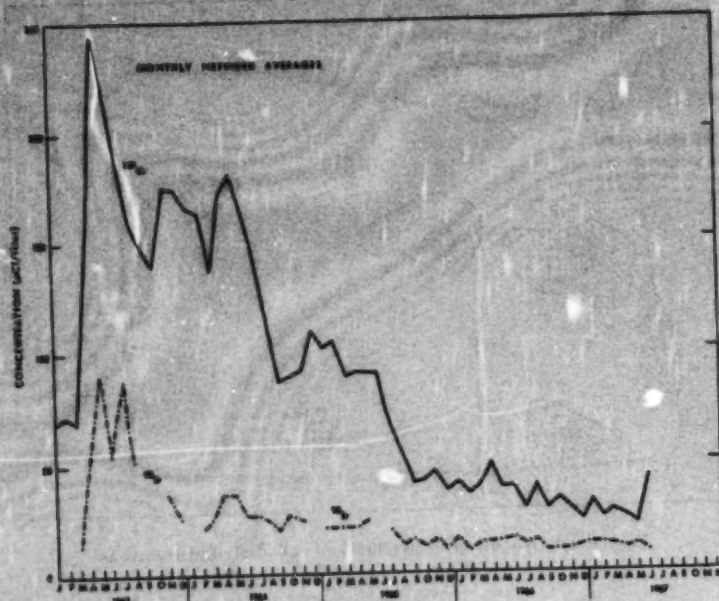


Figure 5. Radionuclide concentrations in Oregon milk network 1963-June 1967

3. Washington Milk Network April-June 1967

*Air Quality and Radiation Control Section
State of Washington Department of Health*

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented in an earlier report (5).

Selected samples are analyzed radiochemically for strontium-90, Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectrometry. Details of the analytical procedures were presented earlier (5).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for April through June 1967. Samples collected during April through June 1967 contained less than 10 pCi/liter of iodine-131. Barium-140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 7 to display general trends.

During this reporting period, three samples were collected (one from Benton County and two from Franklin County) and analyzed for zinc-65. In all three cases, zinc-65 levels were less than 25 pCi/liter. Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
October-December 1966	June 1967
January-March 1967	September 1967

Radiological Health Data and Reports

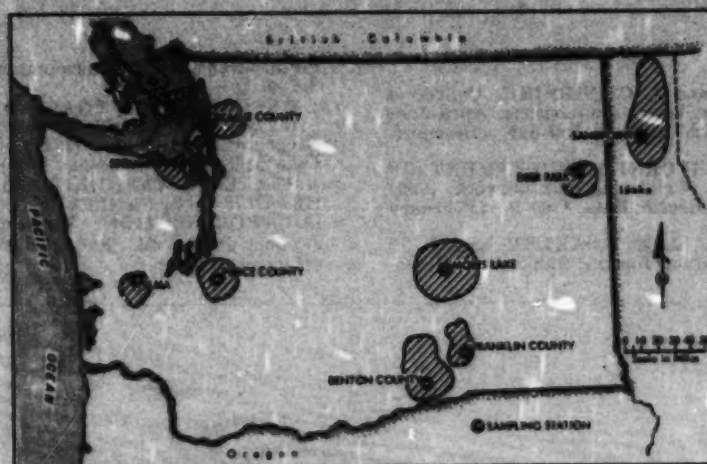


Figure 6. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington raw milk, April-June 1967

Sampling location	Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	April	May	June	April	May	June	April	May	June
Benton County.....	NB	1,330	NB	NB	6	NB	NB	<15	NB
Deer Park.....	1,990	1,190	* 1,110	10	10	13	26	30	* 25
Elma.....	1,180	1,180	* 1,175	6	18	9	22	24	* 20
Franklin County.....	1,210	NB	1,160	4	NB	5	<15	NB	<15
Meese Lake.....	1,380	1,330	* 1,320	6	6	6	15	<15	* <15
Pierce County.....	1,110	1,210	* 1,225	5	18	12	15	46	* 38
Puget Sound.....	1,280	1,280	* 1,215	24	23	12	38	39	* 30
Sequim.....	1,160	1,180	1,200	9	6	8	20	20	* 31
Skagit County.....	1,160	1,130	* 1,220	9	18	15	21	27	* 23
Average.....	1,195	1,306	1,195	9	12	10	22	31	24

* Represents an average of two samples collected at these sampling locations during the month.
NB, no sample collected.

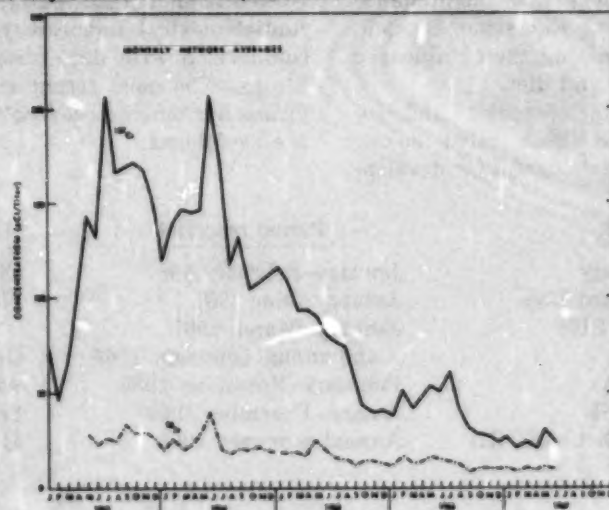


Figure 7. Radionuclide concentrations in Washington milk 1963-June 1967

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- (4) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April-June 1965. *Radiol Health Data* 6:683-684 (December 1965).
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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for develop-

ing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. The most recent reports on these programs in *Radiological Health Data and Reports* are as follows.

Program	Period reported	Last presented
California Diet Study	January-February 1967	October 1967
Connecticut Standard Diet	January-June 1967	November 1967
Institutional Diet, PHS	January-March 1967 and annual summary 1966	October 1967
Teenage Diet, FDA	February-November 1965	August 1966
Tri-City Diet, HASL	August-December 1966	September 1967
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (1). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2-4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively.

Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

¹ Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Activity	Period reported	Last presented
California Water Sampling Program	January-June 1966	June 1967
Coast Guard Water Sampling Program	1966	November 1967
Minnesota Surface Water Sampling Program	January-June 1966	January 1967
New York Surface Water Sampling Program	January-December 1966	September 1967
Radiostromium in Tap Water, HASL	March-November 1966	June 1967
Washington Surface Water Sampling Program	July 1965-June 1966	August 1967

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Gross Radioactivity in Surface Waters of the United States, June 1967

**Division of Pollution Surveillance, Federal
Water Pollution Control Administration,
Department of Interior**

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures

was published in the August 1967 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (1-6). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of

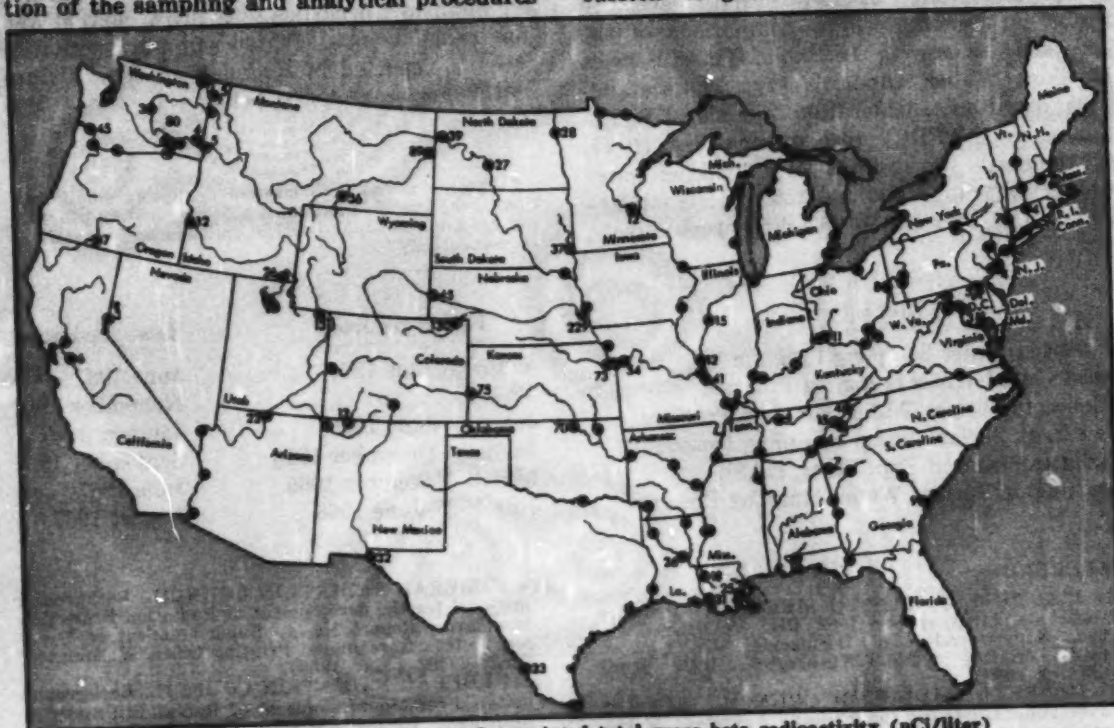


Figure 1. Sampling locations and associated total gross beta radioactivity (pCi/liter) for surface waters, June 1967

Table 1. Radioactivity in raw surface waters, June 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)			Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Missouri River:						
Cedar Hill, N. Mex.	1	1	2	7	3	12	Williston, N. Dak.	8	2	8	29	10	29
Arkansas River:							Bismarck, N. Dak.	2	4	6	10	17	27
Coodes, Kans.	9	10	19	33	37	73	St. Joseph, Mo.	16	3	19	37	17	54
Ponca City, Okla.	17	2	19	57	13	70	North Platte River:						
Atchafalaya River:							Henry, Nebr.	4	8	12	30	25	48
Morgan City La.	3	0	3	24	7	31	Ohio River:						
Frederick, Idaho	1	1	2	5	21	28	Toronto, Ohio	0	0	0	1	7	8
Big Horn River:							Cairo, Ill.	1	1	2	2	4	6
Hardin, Mont.	8	10	18	30	16	36	Pied Grande River:						
Big Horn River:							Albany Falls Dam,						
Sioux Falls, S. Dak.	2	< 1	3	30	17	37	Idaho	0	0	0	1	3	4
Clearwater River:							Platte River:						
Leavitt, Idaho	< 1	0	< 1	2	3	5	Plattsmouth, Nebr.	24	2	26	214	15	229
Clack River:							Potomac River:						
Clinton, Tenn.	0	1	1	1	3	4	Washington, D.C.	0	0	0	0	3	3
Kingsport, Tenn.	0	0	0	< 1	15	15	Rainy River:						
Colorado River:							Baudette, Minn.	0	0	0	1	10	11
Paseo, Ariz.	0	13	13	3	30	33	Red River, North:						
Columbia River:							Grand Forks, N. Dak.	4	3	6	10	18	28
Wenatchee, Wash.	0	0	0	0	3	3	Red River, South:						
Paseo, Wash.	0	0	0	23	55	80	Alexandria, La.	4	0	4	17	9	26
Chickasaw, Ore.	< 1	0	< 1	20	25	45	Rio Grande:						
Connecticut River:							El Paso, Tex.	4	3	7	16	16	32
Exford Dam, Conn.	0	0	0	1	3	4	Laredo, Tex.	1		6	5	18	23
Corn River:							San Joaquin River:						
Rome, Ga.	< 1	1	1	1	6	7	Vernalis, Calif.	1	0	1	3	3	6
Cumberland River:							San Juan River:						
Chatham Lock,							Shiprock, N. Mex.	597	3	602	2,065	13	2,080
Tenn.	0	0	0	1	3	4	Savannah River:						
Delaware River:							Port Wentworth,						
Philadelphia, Pa.	0	0	0	1	3	4	Ga.	< 1	1	1	3	6	9
Great Lakes:							Snake River:						
Duluth, Minn.	0	0	0	1	2	3	Fayette, Idaho	< 1	3	3	5	7	12
Green River:							Wapwal, Wash.	0	0	0	2	2	4
Dutch John, Utah	< 1	2	2	1	13	14	South Platte River:						
Hudson River:							Julesburg, Colo.	22	14	36	100	30	130
Poughkeepsie, N. Y.	0	0	0	2	3	7	Susquehanna River:						
Illinois River:							Conowingo, Md.	0	0	0	1	4	5
Peoria, Ill.	2	1	3	6	9	15	Tennessee River:						
Grafton, Ill.	0	2	2	2	10	12	Chattanooga, Tenn.	0	0	0	0	4	4
Kansas River:							Yellowstone River:						
DeSoto, Kans.	17	1	18	64	9	73	Sidney, Mont.	19	6	25	81	8	89
Klamath River:							Maximum	597	14	602	2,065	53	2,080
Keno, Ore.	0	0	0	1	6	7	Minimum	0	0	0	0	2	3
Maumee River:													
Toledo, Ohio	0	2	2	1	10	11							
Mississippi River:													
St. Paul, Minn.	0	1	1	1	11	12							
E. St. Louis, Ill.	12	1	13	30	11	41							
New Roads, La.	3	0	3	10	8	18							
New Orleans, La.	6	2	8	14	11	25							

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both May and June, the following stations showed alpha radioactivity in excess of 15 pCi/liter for either suspended or dissolved solids:

San Juan River; Shiprock, N. Mex.
South Platte River; Julesburg, Colo.
Yellowstone River; Sidney, Mont.

In June, the following stations showed alpha radioactivity in excess of 15 pCi/liter on suspended solids:

Arkansas River; Ponca City, Okla.
Kansas River; DeSoto, Kans.
Missouri River; St. Joseph, Mo.
Platte River; Plattsmouth, Nebr.

Plattsmouth, Nebr. on the Platte River also showed beta radioactivity in excess of 150 pCi/liter on suspended solids.

The following stations decreased to less than 15 pCi/liter alpha radioactivity or 150 pCi/liter beta radioactivity on either suspended or dissolved solids:

Animas River; Cedar Hill, N. Mex.

Arkansas River; Coolidge, Kan.

Columbia River; Pasco, Wash.

Samples collected June 6 and June 21 at Shiprock, N. Mex., on the San Juan River contained beta radioactivity on suspended solids greatly in excess of 150 pCi/liter. This high value is due to the high solids content of these samples. On a weight basis the average values on suspended solids for these samples were 24 pCi/g for alpha radioactivity and 83 pCi/g for beta radioactivity. These values are not significantly different from the values on a weight basis found in the samples collected on June 14 and June 24. These latter samples yielded values

on a volume basis (pCi/liter) that are normal for this station.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the West-

ern Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

<u>Network</u>	<u>Period</u>	<u>Issue</u>
HASL Fallout Network	July-December 1966	September 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	January-March 1967	September 1967

1. Radiation Surveillance Network August 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity by the station operators. These estimates are made after the decay of radon and partial decay of thoron daughter products and prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are

reported elsewhere on a monthly basis (1). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*. The described procedures have been modified so that laboratory gross beta radioactivity analysis and gamma-ray spectroscopy are no longer performed on air samples having a field estimate below 10 pCi/m³. Reporting field estimates only may cause an apparent increase in the published airborne radioactivity levels proportional to the amount of thoron daughter radioactivity present in the sample. In extreme cases, this increase may be as much as 2 orders of magnitude, but usually will be of the order of a factor of 2 or less. The maximum field estimates reported by the RSN stations attributable to thoron daughter radioactivity have ranged from 15 to 20 pCi/m³ at 5 hours after collection.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates, as measured by the field estimate, and deposition by precipitation during August 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

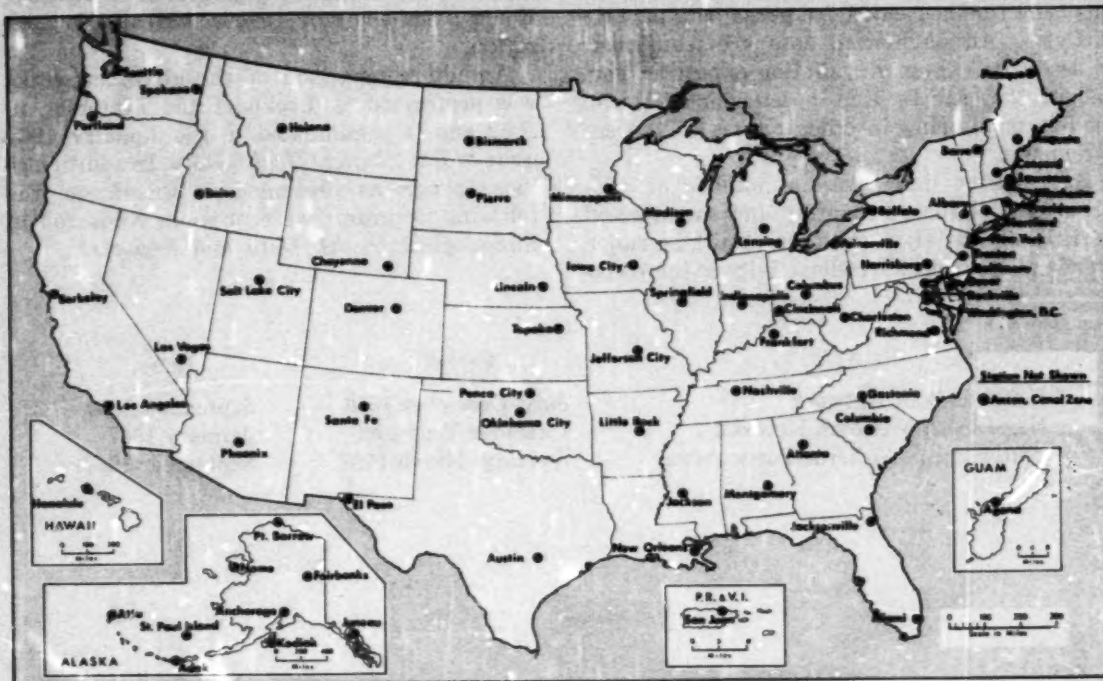


Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, August 1967

Station locations		Number of samples		Air surveillance, gross beta radioactivity (pCi/m ³)			Last profile in RHD&R	Precipitation	
		Air	Ppts	Maximum	Minimum	Average ^a		Total depth (mm)	Total deposition (pCi/m ²)
Ala:	Montgomery	31	6	7.86	0.28	2.45	Nov 67	80	<11
Alaska:	Adak	31		.37	.37	.37	June 67	(b)	
	Anchorage	22	9	.00	.00	.00	Dec 67	67	<14
	Attu Island	(c)					July 67	(b)	
	Fairbanks	(c)					Jan 67	(b)	
	Juneau	18	18	.41	.00	.06	Apr 67	186	<37
	Kodiak	22		.90	.00	.31	May 67	(b)	
	Nome	(c)					Sept 67	(b)	
	Pt. Barrow	31		.05	.31	.61	Aug 67	(b)	
	St. Paul Island	(c)					Oct 67	(b)	
Ariz:	Phoenix	19		2.18	.87	1.55	Apr 67	(b)	
Ark:	Little Rock	29	6	2.90	.31	1.10	Dec 67	90	<30
Calif:	Berkeley	23		.47	.00	.00	May 67	(b)	
	Los Angeles	23		1.80	.24	.60	Sept 67	(b)	
C.E.:	Ancon	19		2.95	.47	1.07	May 67	(b)	
Colo:	Denver	30	5	6.00	.25	1.81	May 67	14	<3
Conn:	Hartford	31	9	1.04	.00	.41	Apr 67	77	<15
Del:	Wilmington	22		1.80	.20	.42	Nov 67	(b)	
D.C.:	Washington	28	10	2.40	.21	.76	Aug 67	242	<40
Fla:	Jacksonville	26	14	.38	.30	.34	Dec 67	277	<55
	Miami	29	11	.29	.15	.22	Apr 67	164	<33
Ga:	Atlanta	27	7	1.80	.37	1.04	Oct 67	123	<28
Guam:	Agaña	30		1.08	.00	.40	Nov 67	(b)	
Hawaii:	Honolulu	31	3	.64	.32	.28	July 67	85	<17
Idaho:	Boise	30		3.06	.78	1.90	July 67	(b)	
Ill:	Springfield	30	4	3.79	.74	2.10	Aug 67	56	<11
Ind:	Indianapolis	28	4	7.80	1.02	3.48	Oct 67	54	<11
Iowa:	Iowa City	27	5	4.60	.21	1.84	May 67	106	<21
Kans:	Topeka	25	6	8.16	.84	3.50	Dec 67	46	<9
Ky:	Frankfort	30	7	5.27	1.11	2.65	Aug 67	44	<9
La:	New Orleans	28	12	.65	.04	.22	Aug 67	261	<53
Mass:	Augusta	29	11	1.49	.21	.44	Sept 67	95	<19
	Presque Isle	11	1	1.78	.34	.78	May 67	6	<1
Md:	Baltimore	23	6	2.81	.19	.86	Apr 67	145	<29
	Rockville	5		1.10	.07	.21	July 67	(b)	
Mass:	Lawrence	27	8	1.75	.00	.45	Nov 67	83	<11
	Winchester	19	10	1.31	.00	.51	Nov 67	61	<12
Mich:	Lansing	31	6	6.01	1.40	2.96	July 67	73	<15
Minn:	Minneapolis	23	5	.85	.17	.26	Nov 67	124	<25
Miss:	Jackson	29	3	2.18	.25	.98	Sept 67	57	<11
Mo:	Jefferson City	31	3	4.34	.59	1.93	Oct 67	50	<10
Mont:	Helena	31	3	2.80	.81	1.68	June 67	14	<3
Nebr:	Lincoln	23	6	4.60	.77	1.99	Oct 67	49	<10
Nev:	Las Vegas	31		1.60	.47	.74	Jan 67	(b)	
N.H.:	Concord	22		3.10	.46	1.12	Aug 67	(b)	
N.J.:	Trenton	31	10	.58	.19	.29	Sept 67	46	<9
N. Mex:	Santa Fe	30	14	1.83	.22	.79	June 67	50	<16
N.Y.:	Albany	23	6	2.00	.20	.83	Oct 67	70	<14
	Buffalo	17		.67	.10	.28	May 67	(b)	
	New York	29		.38	.16	.23	June 67	(b)	
N.C.:	Charlotte	1	6	5.78	5.78	5.78	May 67	145	<29
N. Dak:	Bismarck	30	5	5.09	.47	2.07	Aug 67	24	<5
Ohio:	Cincinnati	13		7.12	.26	2.34	Nov 67	(b)	
	Columbus	29	1	7.01	.42	2.71	Sept 67	37	<7
	Fainesville	30	10	2.17	.32	1.13	Apr 67	41	<9
Okla:	Oklahoma City	28	3	1.92	.00	1.01	July 67	89	<12
	Ponca City	25	6	1.39	.23	.72	Apr 67	43	<6
Ore:	Portland	30		1.25	.22	.42	Oct 67	(b)	
Pa:	Harrisburg	28	3	4.24	.85	1.66	Oct 67	100	<30
P.R.:	San Juan	23	5	1.22	.00	.24	Sept 67	79	<16
R.I.:	Providence	27	5	.68	.00	.20	July 67	116	<23
S.C.:	Columbia	16	9	11.61	.00	2.27	June 67	244	<49
S. Dak:	Pierre	31	3	9.40	1.92	4.55	Apr 67	10	<3
Tenn:	Nashville	31	7	3.20	.30	1.16	July 67	43	<9
Tex:	Austin	31	3	7.61	1.71	4.20	Nov 67	65	<13
	El Paso	30	4	3.44	.57	1.51	Aug 67	14	<3
Utah:	Salt Lake City	31	4	1.35	.31	.92	Sept 67	5	<1
Vt:	Barre	29		3.61	.24	1.65	Dec 67	92	<19
Va:	Richmond	27	10	1.65	.23	.77	Dec 67	157	<31
Wash:	Seattle	30		.45	.00	.14	Dec 67	(b)	
	Spokane	31		1.97	.65	1.17	Nov 67	(b)	
W. Va.:	Charleston	31	9	3.92	.48	1.56	June 67	64	<13
Wis:	Madison	31	6	50.75	.18	2.61	Dec 67	57	<11
Wyo:	Cheyenne	31	3	5.72	2.19	3.90	Jan 67	23	<6
Network summary		1,829	339	50.75	0.00	1.29		84	<17

^a The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

^b No precipitation sample collected.

^c No report received.

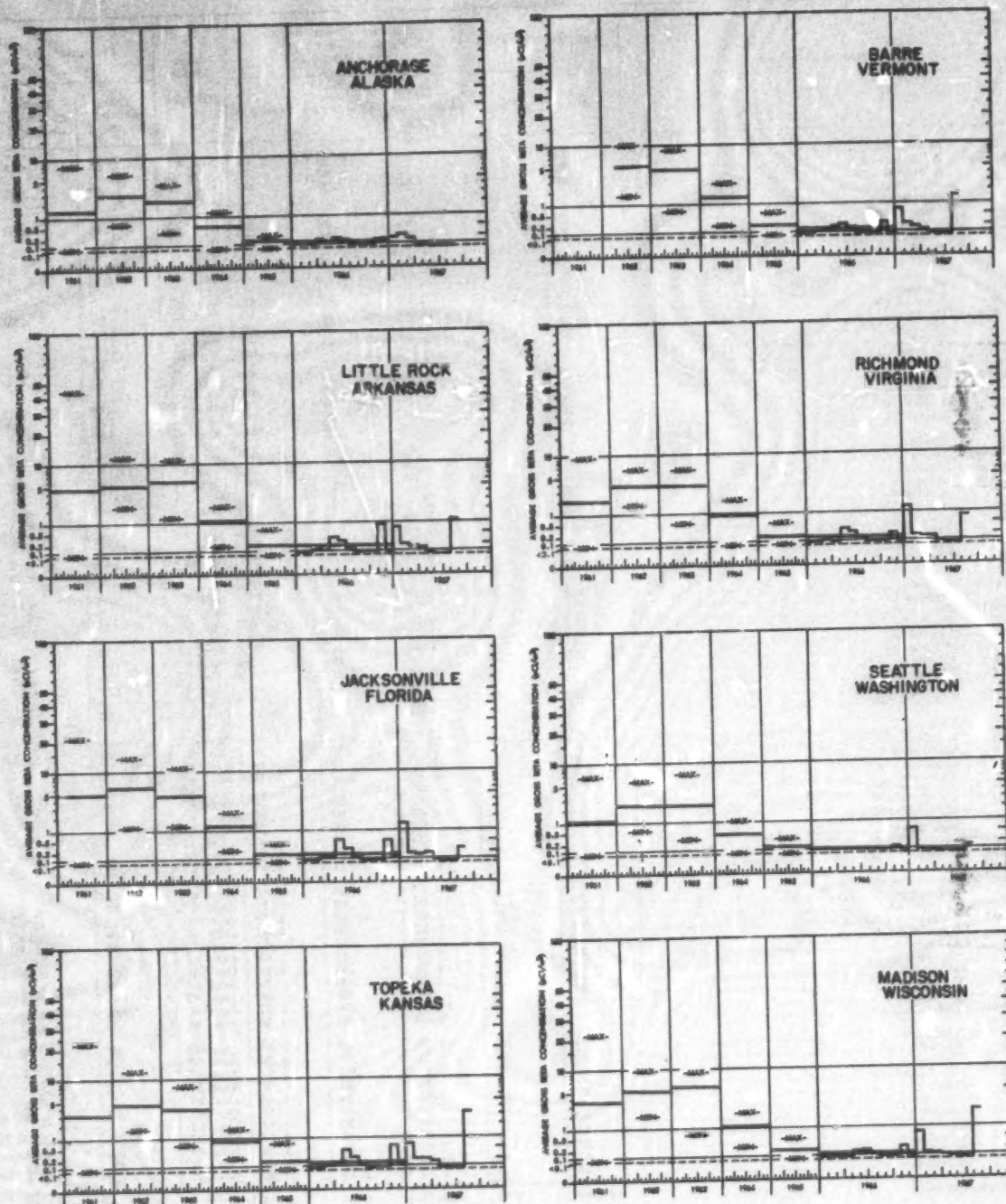


Figure 2. Monthly and yearly profiles of beta radioactivity in air—
Radiation Surveillance Network, 1961-August 1967

Air and precipitation radioactivity levels remained near or below detectable levels. The only sample that contained a significant amount of radioactivity was the August 2 air sample from Madison, Wisc. This filter contained a single particle of radioactive material which emitted beta particles of about 1.75 MeV maximum energy, had a half life of approximately 15 days, and emitted no alpha or gamma radiation when analyzed in the laboratory on August 7-14. The material has been tentatively identified as phosphorus-32. The source of the contamination is not known.

2. Canadian Air and Precipitation Monitoring Program, August 1967¹

Radiation Protection Division, Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection sta-

tions are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of the National Health and Welfare (2-6).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for August 1967 are presented in table 2.

¹ Prepared from information and data in the September 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

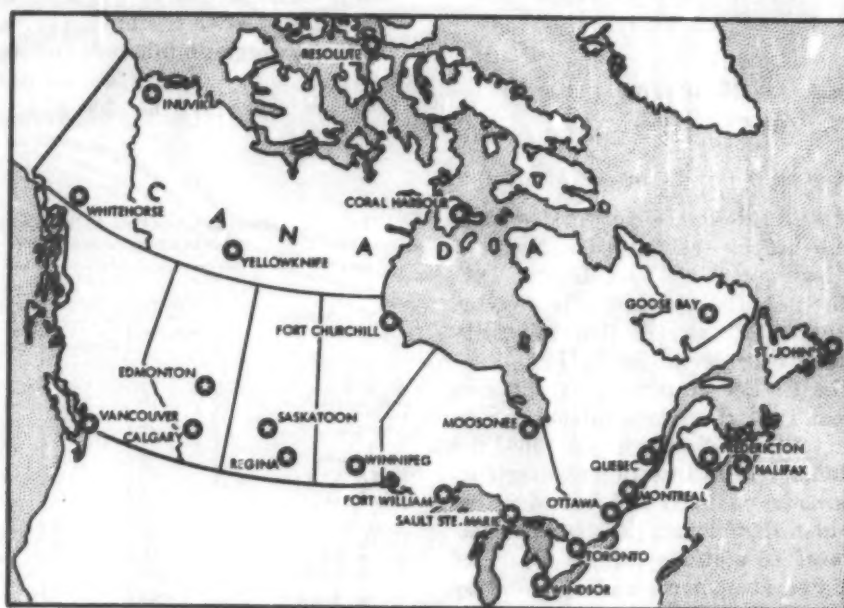


Figure 3. Canadian air and precipitation sampling stations

Table 2. Canadian gross beta radioactivity in surface air and precipitation, August 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m ³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m ²)
Calgary	31	1.17	0.0	0.4	43	0.6
Coral Harbour	31	.0	.0	.0	15	.4
Edmonton	31	.0	.0	.0	18	.8
Ft. Churchill	31	.0	.0	.0	5	.3
St. William	31	.0	.0	.0	19	1.4
Fredericton	31	.0	.0	.0	10	.5
Geese Bay	30	.0	.0	.0	6	.6
Halifax	31	.0	.0	.0	5	.7
Inuvik	31	.0	.0	.0	9	.3
Saskatoon	30	.1	.0	.0	11	.8
Moncton	31	.0	.0	.0	13	1.0
Ottawa	31	.0	.0	.0	13	.8
Quebec	31	.0	.0	.0	7	1.1
Sagina	31	1.01	.0	.3	39	.7
Resolute	30	.0	.0	.0	NS	NS
St. John's, Nfld.	31	.0	.0	.0	11	.5
Saskatoon	31	1.15	.0	.4	12	.7
Sault Ste. Marie	31	.0	.0	.0	8	.7
Toronto	31	.0	.0	.0	20	.8
Vancouver	31	.0	.0	.0	48	.3
Whitehorse	31	.0	.0	.0	32	.3
Windsor	30	.0	.0	.0	11	1.0
Winnipeg	31	.0	.0	.0	16	.9
Yellowknife	31	.0	.0	.0	75	.3
Network summary	740	1.17	0.0	0.4	19	0.7

NS, no sample collected.

3. Mexican Air Monitoring Program August 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members

of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20 hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average gross beta radioactivity in surface air during August 1967 are presented in table 3.

Table 3. Mexican gross beta radioactivity of airborne particulates, August 1967

Station	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average
Acapulco	9	0.2	<0.1	0.1
Chihuahua	9	.1	<.1	.1
Ciudad Juárez	6	.1	<.1	.1
Ensenada	17	.1	<.1	.1
Guadalajara	8	.1	<.1	<.1
Guaymas	NS			
La Paz	3	.1	<.1	
Matamoros	NS			
Matatlán	12	.1	<.1	.1
Mérida	12	.2	<.1	.1
México, D.F.	20	.1	<.1	.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	11	.1	<.1	<.1
Torreón	14	.1	<.1	<.1
Veracruz	21	.1	<.1	<.1

NS, no sample collected, station temporarily shut down.



Figure 4. Mexican air sampling locations

4. Pan American Air Sampling Program August 1967

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network before July 31, 1967. The air sampling locations are shown in figure 5.

The August 1967 air monitoring results are given in table 4. Airborne gross beta radioactivity levels remained elevated at all reporting stations south of the equator although they were substantially lower than those reported for July 1967. Those samples more active than 1.0 pCi/m^3 at the time of collection are presented in table 5.



Figure 5. Pan American Air Sampling Program stations

Table 4. PAHO gross beta radioactivity in surface air August 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m ³)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires.....	9	0.88	0.64	0.76
Bolivia: La Paz.....	29	1.73	.35	.90
Chile: Santiago.....	24	.65	.39	.50
Colombia: Bogotá.....	31	.17	.00	.05
Ecuador: Guayaquil.....	30	.60	.04	.35
Jamaica: Kingston.....	18	.65	.04	.08
Peru: Lima.....	27	.82	.09	.37
Venezuela: Caracas.....	23	.17	.01	.05
West Indian: Trinidad.....	17	.19	.01	.06
Pan American summary.....	190	1.73	0.09	0.34

* The monthly average is calculated by weighting the individual samples with length of sampling period.

Table 5. Samples from PAHO member country which contained radioactivity greater than 1 pCi/m³

Location	Date August 1967	Gross beta radioactivity at collection (pCi/m ³)
Bolivia: La Paz.....	5-6	1.73
	7-8	1.27
	9-11	1.39
	12-14	1.60
	15	1.80

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained

from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring in the vicinity of nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Release of radioactive materials from AEC installations are governed by radiation protection standards set forth by AEC's Division of

Operational Safety in directives published in the "AEC Manual."¹

Summaries of the environmental radioactivity data follow for the Brookhaven National Laboratory and the Los Alamos Scientific Laboratory.

¹ Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Brookhaven National Laboratory January-June 1967¹

*Associated Universities, Inc.
Upton, New York*

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by discharge of coolant air from the graphite research reactor, (2) by radiation from an ecology forest gamma-ray source, and (3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

¹ Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the First Half of 1967," Associated Universities Inc., Upton, N. Y.



Figure 1. Brookhaven National Laboratory and surrounding area

Area monitoring

The radioactivity in the discharge coolant air is almost entirely due to argon-41, a beta-particle gamma-ray emitter. Monitoring for argon-41 is performed by continuously measuring the gamma-ray exposure rate in milliroentgens per week (mR/wk), rather than the concentration in air, at four stations located along the site perimeter (figure 2). These same stations monitor radioactivity resulting from a 10,000 curie cesium-137 gamma-ray source, situated in an ecology forest, about 800 meters equidistant from the north and east boundaries of the BNL.

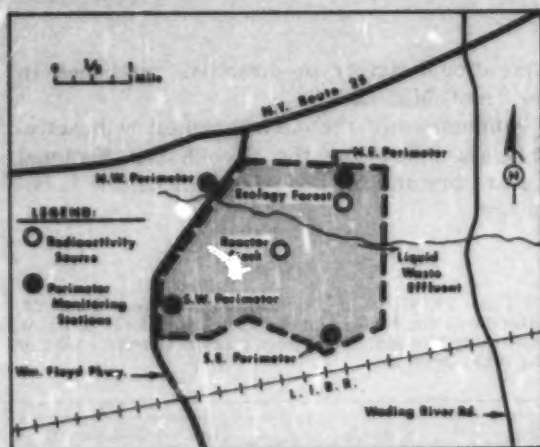


Figure 2. Brookhaven National Laboratory monitoring station locations

Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to the ecology forest source. However, the radiation levels at this location are within the established AEC radiation protection standard which is 0.5 rem/yr for individuals in the general population. The average weekly radiation levels at the Brookhaven National Laboratory site perimeter, due to laboratory operations, are given in table 1. Values of radiation background levels undisturbed by laboratory operations have also been included in table 1 for purposes of comparison.

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the

Table 1. External gamma radioactivity at BNL site perimeter, January-June 1967

Period 1967	Average exposure rates (mR/wk)			
	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast perimeter
January.....	0.04	0.28	0.22	1.79
February.....	.04	.10	.24	1.77
March.....	.09	.22	.25	1.22
April.....	.18	.14	.18	1.77
May.....	.29	.04	.45	2.22
June.....	.22	.09	.04	2.08
January-June.....	.15	.16	.28	2.02
Maximum weekly average	0.57	0.73	1.00	4.46
Undisturbed background	1.82	1.75	1.76	1.82

BNL site. The average concentration and total amount of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 2 for January-June 1967.

Table 2. Gross beta radioactivity in liquid waste effluent at BNL site boundary, January-June 1967

Period 1967	Average radioactivity concentration (pCi/liter)	Total radioactivity concentration discharged (mCi)
January.....	20	1.4
February.....	27	1.5
March.....	260	20.3
April.....	55	5.5
May.....	31	2.5
June.....	21	2.2
January-June.....	68	33.4

Analysis of composite samples of the effluent has shown that, on the average, no more than 20 percent of the radioactivity consists of strontium-90 and that no appreciable amounts of radioactive iodine or radium and other bone-seeking radionuclides are present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 3,000 pCi/liter.

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January-June 1966	December 1966
July-December and annual summary 1966	June 1967

2. Los Alamos Scientific Laboratory Calendar Year 1966

University of California
Los Alamos, New Mexico

As part of the environmental monitoring program at Los Alamos, measurements of radioactivity in airborne particulates and precipitation are made periodically. The samples have been taken on the roof of building TA-50 (about 1 $\frac{1}{4}$ miles southeast of the Administrative Building) since March 1963.

Air monitoring

Airborne radioactive particulate matter is collected on 4-inch-diameter filters. The sampling rate was reduced from 46 m³/hr in 1962 to 25.5 m³/hr in 1963, due to the addition of an activated charcoal filter behind the first filter. Air samples are ordinarily collected for 24-hour intervals during the work week, 72-hour weekend samples are collected.

The filters are counted for beta radioactivity 7 days after collection in a thin-window methane-flow proportional counter with an overall efficiency for strontium-yttrium-90 of 50 percent.

In September 1966, a large chamber was added to the low background beta-particle counting system that permits the counting of these air samples in the same geometry as the precipitation samples. The efficiency for strontium-yttrium-90 remains the same as in the older counter.

^a Summarized from "Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico for 1966," (LA-3663).

Precipitation monitoring

Collection is made in a 0.4 square meter rain collector which delivers 1 liter of water for each 0.1 inch of precipitation. It has been found that this arrangement also collected radioactivity from dry deposition onto the collector. By washing down the sides of the collector with 1 liter of distilled water, a suitable sample is obtained. These "wash" samples, as well as any precipitation, are reduced in volume, dry-plated on 1-inch stainless steel planchets, and counted in an automatic beta-particle counting system.

Results

Average daily radioactivity concentrations for air collected are weighted for sample periods of more than 1 day. Average radioactivity concentrations for the precipitation collection are calculated from the total radioactivity collected during the month divided by the number of days in the month. Summary of air data (pCi/m³) shows the maximum, 4.64; minimum, 0.00; and average, 0.15. Precipitation (nCi/m²) shows the maximum, 4.2; minimum, 0.0; and average, 0.1. Total precipitation for the year was 43.6 nCi/m².

Recent coverage in Radiological Health Data:

Period	Issue
1962-1963	October 1964
1964	November 1965

Reported Nuclear Detonations, November 1967

During November 1967, one U.S. underground nuclear test was announced by the Atomic Energy Commission. A nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground on November

8, 1967 by the Atomic Energy Commission at its Nevada Test Site.

U.S. Underground Nuclear Test

The test was conducted at the Nevada Test Site, which is located in the southern part of the state. The test was a low yield test, with a yield of less than 20 kilotons TNT equivalent. The test was conducted on November 8, 1967, and was the only U.S. underground nuclear test reported for the month of November 1967.

The test was conducted by the Atomic Energy Commission, which is responsible for the management of the Nevada Test Site. The test was a low yield test, with a yield of less than 20 kilotons TNT equivalent. The test was conducted on November 8, 1967, and was the only U.S. underground nuclear test reported for the month of November 1967.

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SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

X-RAY PATTERNS AND INTENSITIES FROM HIGH VOLTAGE SHUNT REGULATOR TUBES FOR COLOR TELEVISION RECEIVERS. H. F. Stewart, N. F. Modine, E. G. Murphy and J. W. Rolofson. *Radiological Health Data and Reports*, Vol. 8, December 1967, pp. 675-686.

Recently, X-ray emission from some color television receivers greater than the NCRP recommended maximum came to the attention of the Public Health Service. The radiation came from a high voltage shunt regulator tube. This discovery prompted a general investigation by the Public Health Service of radiation emission from regulator tubes used in color television receivers. This report describes the construction of high voltage shunt regulator tubes, laboratory test methods, and the measured X-ray distributions in direction, quality and intensity from 327 shunt regulator tubes.

KEYWORDS: Shunt regulator tubes, television receivers, X ray.

MEASUREMENTS OF X-RAY EXPOSURE FROM A HOME COLOR TELEVISION RECEIVER. H. J. Rechen, T. R. Lee, R. H. Schneider, and O. G. Briscoe. *Radiological Health Data and Reports*. Vol. 8, December 1967, pp. 687-697.

A detailed examination of X-ray leakage has been made for two prototypes of the KC chassis manufactured by General Electric Company for home color television receivers. Typical operating conditions relevant to X-ray production from the high voltage shunt regulator tube and the cathode ray tube are presented. A selected 6EF4 tube, under operating conditions chosen to produce maximum X-ray emission, produces an exposure rate of 83 R/hour immediately at the floor level under a console receiver, and a calculated maximum exposure rate of 800 R/hour below the receiver.

The results of using two different instruments to measure X-ray exposure rates are given, an ion chamber and X-ray film, and the results compare within reasonable limits. Preliminary findings of X-ray emission from the high voltage rectifier tubes are discussed. Little is known of the mechanisms that cause rectifiers to emit X rays, or how such emissions may be controlled other than by shielding.

KEYWORDS: Exposure rates, rectifier tubes, shunt regulator tubes, television receivers, X ray.